

Chapter 6

Smoke Test for Cabin Materials

6.1 Scope

- 6.1.1 This test method is used to determine the smoke generating characteristics of airplane passenger cabin interior materials to demonstrate compliance with the requirements of FAR 25.853.

6.2 Definitions

- 6.2.1 Specific Optical Density (D_s)-Specific Optical Density

Specific optical density (D_s)-specific optical density is a dimensionless measure of the amount of smoke produced per unit area by a material when it is burned. In this test, the maximum value of D_s that occurs during the first 4 minutes of a test, 4D_m , is reported.

6.3 Test Apparatus

- 6.3.1 Required Equipment

The test chamber and related equipment (e.g., radiant heat furnace, heat flux density gauge, specimen holders, photometric system, multidirectional pilot burner, etc.) are defined as follows.

- 6.3.1.1 Test Chamber

The test chamber will be a square-cornered box with inside dimensions of 36 ± 0.13 inches (914 ± 3 mm) wide, 24 ± 0.13 inches (610 ± 3 mm) deep, and 36 ± 0.13 inches (914 ± 3 mm) high. A typical test chamber is shown in figure 6-1. The location or size of items such as the chamber door, chamber controls, flowmeters, etc., is optional except as mandated in the following sections.

- 6.3.1.1.1 The interior surfaces (except for the chamber door, vents, etc.) will be porcelain-enameled metal or equivalent coated metal that is resistant to chemical attack and corrosion and suitable for periodic cleaning. The chamber will be equipped with a door such as that indicated in figure 6-1 to provide convenient access for changing test specimens and for cleaning the chamber walls as required. The door will have a viewing window to observe the sample and pilot flamelets behavior during a test, especially when any of the flamelets extinguish (see section 6.7.2.10).

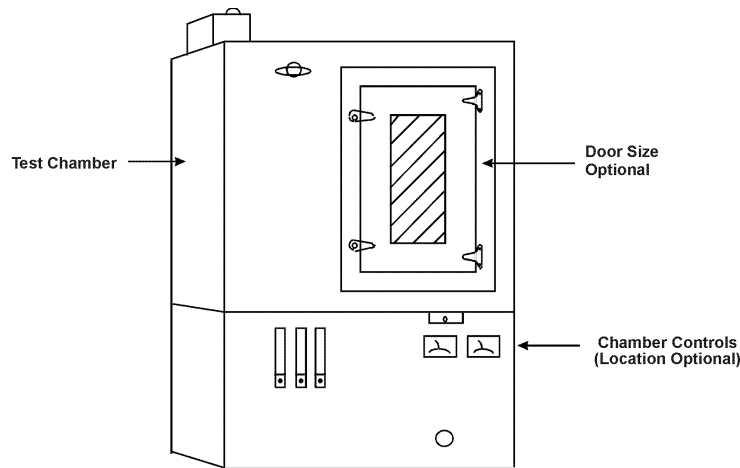


Figure 6-1. Typical Smoke Density Chamber

- 6.3.1.1.2 An inlet-outlet vent for pressure equalization will be provided. The vent and chamber door will have a seal so that when it is closed during tests, there will be no leakage of chamber contents and a small positive pressure can be developed and maintained inside the test chamber.
- 6.3.1.2 Manometer
- A device such as a manometer or pressure transducer will be provided to monitor chamber pressure and leakage. The device will have a range up to 6 inches (152 mm) of water and be connected to a suitable port in the test chamber.
- 6.3.1.3 Pressure Regulator
- A pressure regulator will be provided that consists of a water-filled bottle vented to a suitable exhaust system and a piece of tubing, not to exceed 10 feet (305 cm) in length, that has an inside diameter of at least 1 inch (25 mm). One end of the tubing will be connected to a port within 6 inches of the top of the chamber; the other end of the tubing will be held in position 4 inches (102 mm) below the water surface.
- 6.3.1.4 Test Chamber Wall Thermocouple
- The temperature of the test chamber wall will be monitored by a thermocouple suitable for measuring a temperature of 35°C. The thermocouple will be mounted with its junction secured to the geometric center of the inner rear wall panel of the chamber using an electrically insulating disk cover.
- 6.3.1.5 Electric Power
- A single-phase electric power of 650 W of 115 V, 60 Hz will be provided for the radiant heat furnace and accessories. Where line voltage fluctuations exceed 2.5 percent, a constant voltage transformer will be provided.
- 6.3.1.6 Radiant Heat Furnace
- An electric furnace and associated controlling devices (see figures 6-2 and 6-3) will be provided that are capable of providing a constant thermal flux density of $2.5 \pm 0.05 \text{ W/cm}^2$ ($2.2 \pm 0.04 \text{ Btu/ft}^2/\text{second}$) on the specimen surface.
- 6.3.1.6.1 Furnace Construction
- The dimensions shown in figure 6-2 for the electric furnace are critical. The furnace will be located centrally along the long axis of the chamber, with the opening facing toward and approximately 12 inches (305 mm) from the right wall. The centerline of the furnace will be approximately 7.75 inches (197 mm) above the chamber floor.
- 6.3.1.6.2 Heating Element
- The heating element will consist of a coiled wire capable of dissipating about 525 W. With the furnace installed, the heating element will be positioned so that the coil loops are at the 12 o'clock position, as shown in figure 6-3.
- 6.3.1.6.3 Furnace Control System
- The furnace control system will be capable of controlling the radiant heat output at the required level of $2.5 \pm 0.05 \text{ W/cm}^2$ ($2.2 \pm 0.04 \text{ Btu/ft}^2/\text{second}$), as measured by the heat flux density gauge, under steady-state conditions with the chamber door closed for at least 5 minutes. The control system will consist of an AC solid-state voltage or power controller and a voltmeter or other means for monitoring the electrical input.

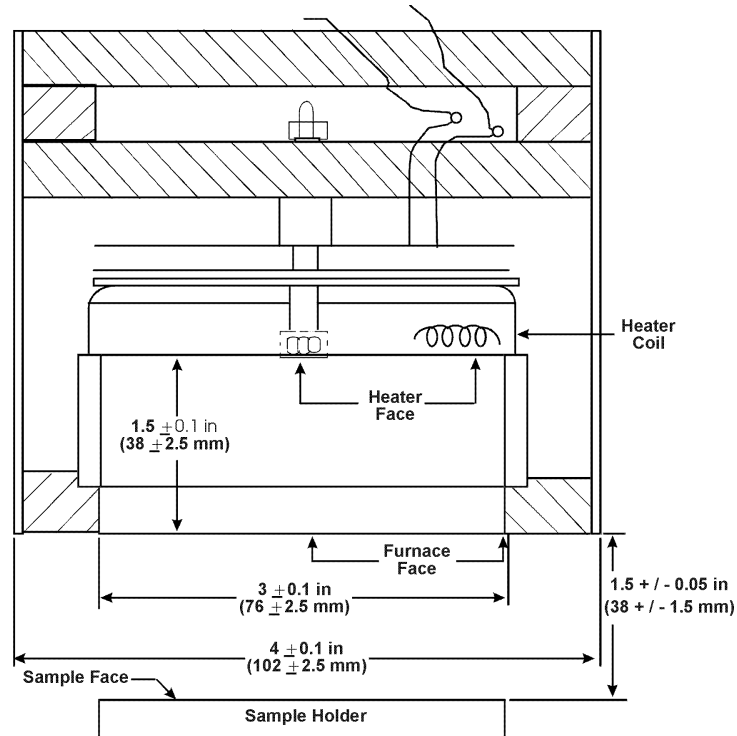


Figure 6-2. Furnace Section

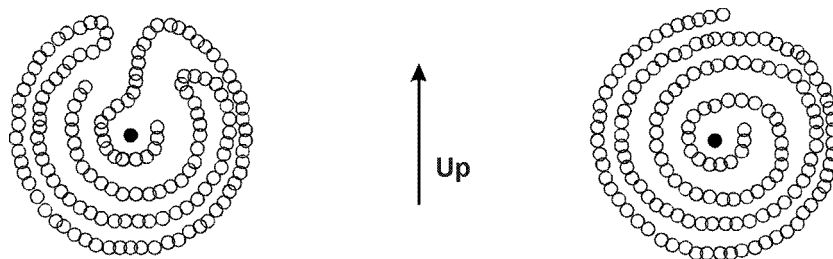


Figure 6-3. Heater Orientation

6.3.1.6.4 Heat Flux Density Gauge

An air-cooled heat flux density gauge will be provided for calibrating the output of the radiant heat furnace. The heat flux density gauge will be a circular foil type, the operation of which was described by Gardon.

- 6.3.1.6.4.1 Compressed air at a pressure of 15 to 30 psi (0.1 to 0.21 MPa) will be provided to cool the heat flux density gauge. The body temperature of the heat flux density gauge will be monitored with a thermometer having an accuracy of 2°F (1°C) at 200°F (93°C) in a 0.5- by 0.5- by 1.5-inch (13- by 13- by 38-mm) -long brass or copper well drilled to accept the thermometer with a close fit. Silicone grease will be used to provide good thermal contact. The circular receiving surface of the heat flux density gauge will be spray-coated with an infrared-absorbing black paint. The heat flux density gauge will be calibrated calorimetrically using a procedure that is acceptable to the FAA Administrator.

6.3.1.7 Pilot Burner

The pilot burner will be a multiple flamelet type with six tubes, as shown in figure 6-4. The six tubes will be fabricated from stainless steel tubing having an outer diameter of 0.125 inch (3.2 mm) and an inner diameter of 0.055 inch (1.4 mm) \pm 0.001 inch (0.025 mm). The six tubes will be attached to a common manifold, as shown in figure 6-4, fabricated from stainless steel tubing having an outer diameter of 0.25 inch (6.4 mm) and a wall thickness of 0.035 inch (0.9 mm). One end of the manifold will be closed and the other end will be attached to a gas supply fitting on the chamber floor.

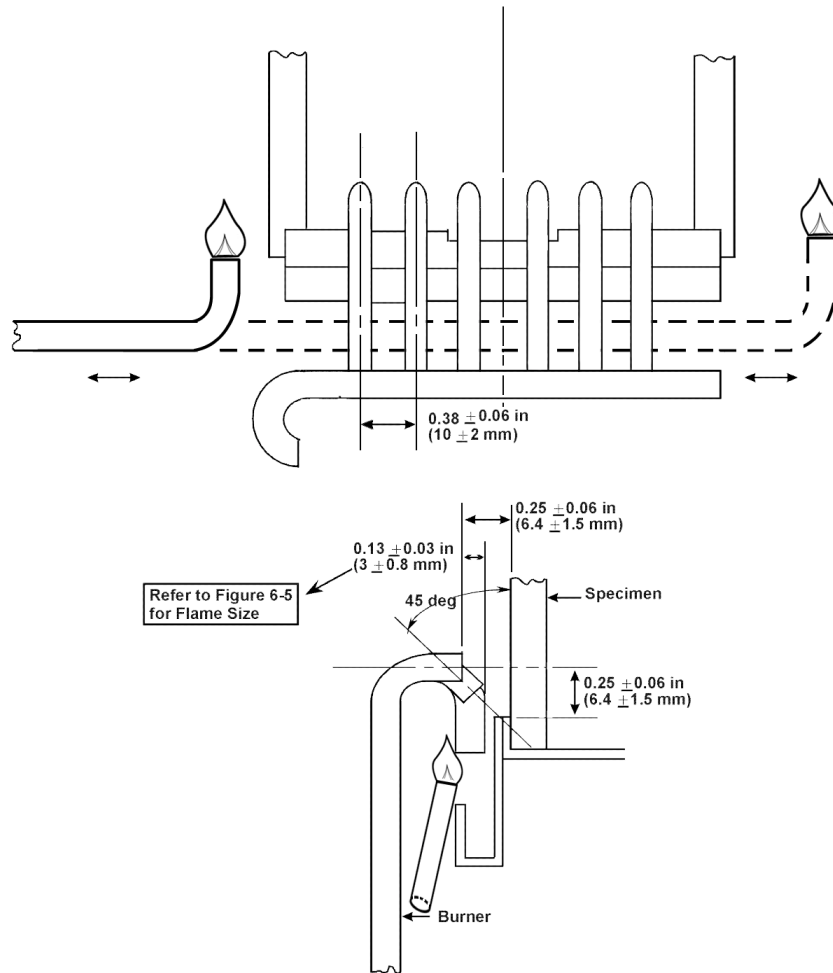


Figure 6-4. Alignment of Holder and Burner

- 6.3.1.7.1 The two outer tubes of the pilot burner will be directed perpendicular to the surface of the specimen. The two inner tubes will be directed at an angle of 45 degrees downward. The two intermediate tubes will be directed vertically downward into the drip pan of the specimen holder.
- 6.3.1.7.2 The pilot burner will be centered in front of and parallel to the specimen holder. The tips of the two outer tubes will be placed 0.25 ± 0.06 inch (6.4 ± 1.6 mm) above the lower opening of the specimen holder and 0.25 ± 0.03 inch (6.4 ± 0.8 mm) away from the face of the specimen surface.

6.3.1.8 Pilot Burner Fuel

The gas fuel for the pilot burner will be prepared by mixing filtered oil-free air with 95 percent minimum purity propane. This mixture will then be fed to the pilot burner. Each gas will be metered through separate, calibrated flowmeters and needle valves. The air-propane mixture will consist of an air flow rate equivalent to 0.018 ± 0.001 ft³/min (500 ± 20 cm³/min) at standard temperature and pressure (STP) and a propane flow rate equivalent to 0.0018 ± 0.0001 ft³/min (50 ± 3 cm³/min) at STP. The compressed air supply will be fed to its flowmeter at 20 ± 5 psi (0.14 ± 0.03 MPa) and the propane at 15 ± 3 psi (0.1 ± 0.02 MPa).

- 6.3.1.8.1 The visible parts of the pilot burner flamelets should be approximately 0.25 inch (6 mm) long with a luminous inner cone approximately 0.13 inch (3 mm) long, as shown in figure 6-5. If the flamelets are not that approximate size, there is probably a difficulty with the air/propane fuel mixture and/or flow rate(s), in which case the accuracy of the flowmeters should be checked.

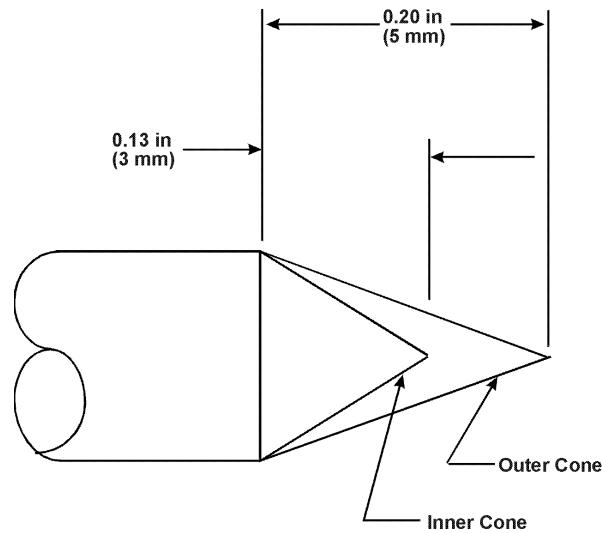


Figure 6-5. Flame Size

6.3.1.9 Specimen Holder

The specimen holder will consist of a stainless steel frame, a backing made of insulation millboard, a spring and retaining rod to secure the specimen in place, and aluminum foil for wrapping the specimen.

6.3.1.9.1 Specimen Holder Frame

The specimen holder frame will be fabricated of stainless steel sheet by bending and brazing (or spot welding) stainless steel sheet of 0.025 ± 0.002 inch (0.64 ± 0.05 mm) nominal thickness to conform in shape and dimension to figure 6-6. The frame will be at least 1.5 inches (38 mm) deep and will provide an exposed specimen surface that is nominally 2.56 by 2.56 inches (65 by 65 mm) and that is at least 6.5 inches² (4,194 mm²) in area.

- 6.3.1.9.1.1 A drip pan to catch and retain dripping material will be attached to the bottom front of the holder.

- 6.3.1.9.1.2 Guides to permit accurate alignment of the exposed specimen area in front of the furnace opening will be attached to the top and bottom of the holder frame.

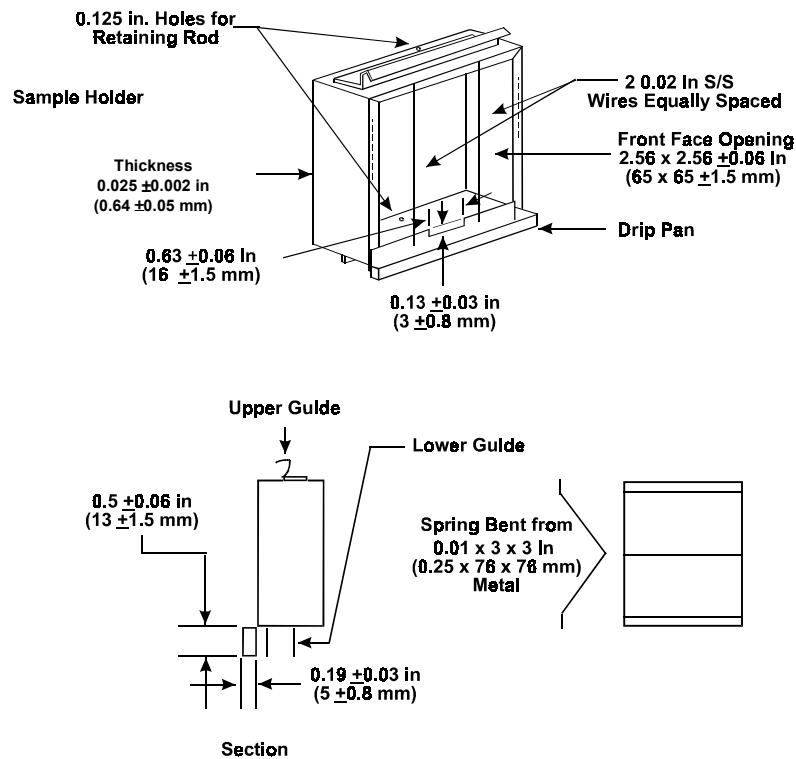


Figure 6-6. Details of Specimen Holder

6.3.1.9.1.3 Two wires made of 0.02 ± 0.005 -inch (0.5 ± 0.12 -mm) diameter stainless steel, vertically oriented and evenly spaced (0.85 inch from the edge of the holder's vertical face openings and 0.85 inch from each other), will be attached to the holder face.

6.3.1.9.2 Specimen Backing

A piece of insulation millboard will be used as a backing for the specimen and as a simulated blank specimen. The millboard will be nominally 0.5 inch (13 mm) thick with a density of 50 ± 10 lb/ft³ (0.8 ± 0.16 g/cm³), or equivalent. Pieces will be cut 2.91 ± 0.03 inches by 2.91 ± 0.03 inches (74 ± 1 mm by 74 ± 1 mm) to fit inside the specimen holder.

6.3.1.9.3 Retaining Spring

A spring bent from a 3- (76-mm) by 2.94- (75-mm) by 0.01-inch (0.25-mm) -thick stainless steel sheet will be used with a stainless steel retaining rod to securely hold the specimen and millboard backing in position during testing.

6.3.1.9.4 Aluminum Foil

Smooth aluminum foil that is 0.0012 ± 0.0005 inch (0.03 ± 0.01 mm) thick will be used to wrap test specimens prior to their insertion in the holder.

6.3.1.10 Support for Radiant Heat Furnace and Specimen Holder

A typical support frame to support the radiant heat furnace and specimen holder is shown in figure 6-7. This support frame will have a provision to establish accurate alignment for the furnace opening so that it is 1.5 ± 0.031 inches (38 ± 1 mm) away from, parallel to, and centered with the exposed specimen surface. Adjustment screws will be provided to align the furnace with reference to the specimen.

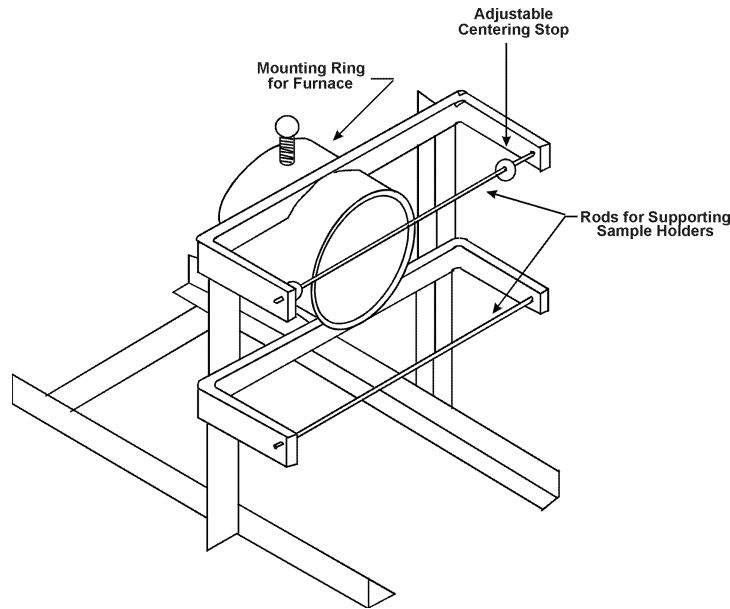


Figure 6-7. Typical Furnace Support

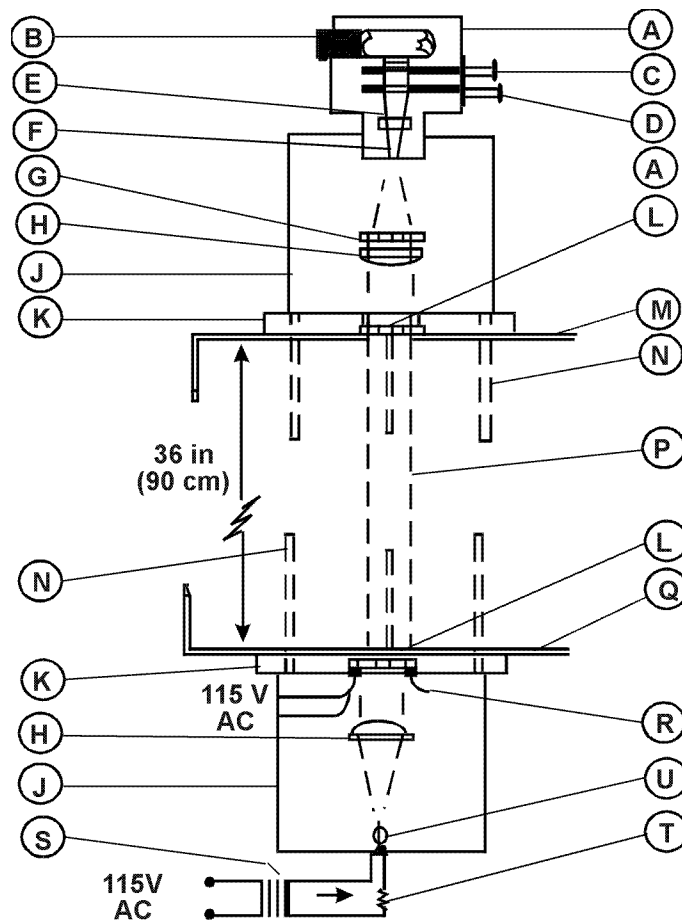
The framework will have two 0.38-inch (10-mm) -diameter transverse rods of stainless steel to accept the guides of the specimen holder. The rods will support the holder so that the exposed specimen surface is parallel to the furnace opening. Spacing stops will be mounted at both ends of each rod to permit rapid and accurate lateral positioning of the specimen holder. An externally operated control rod will be provided to replace the test specimen with the blank specimen holder in front of the furnace.

6.3.1.11 Photometric System

A photometric system capable of detecting light transmittance values of 1 percent minimum to an accuracy of 0.03 percent will be provided. The system will consist of a light source and photomultiplier tube that are oriented vertically to reduce measurement variations due to stratification of the smoke in the chamber during the test, a photomultiplier microphotometer that converts the photomultiplier tube output either to relative intensity and/or to optical density, and a strip chart recorder or other suitable means to record light transmission versus time. A typical system is shown in figures 6-8 and 6-9.

6.3.1.11.1 Light Source

The light source will be an incandescent lamp mounted in a sealed, lighttight box below the chamber floor, operated at a light brightness temperature of $2200 \pm 100\text{K}$ controlled by a constant-voltage transformer. The box will contain the necessary optics to produce a collimated light beam 1.5 ± 0.13 inches (38 ± 3 mm) in diameter, passing vertically up through the chamber. The light source and its optics will be isolated from the chamber atmosphere by a glass window that is mounted flush with the chamber bottom panel and sealed to prevent leakage of chamber contents. To minimize smoke condensation, the window will be provided with a ring-type electric heater mounted in the lighttight box, out of the light path, that maintains a minimum window temperature of 125°F (52°C) on the surface of the window inside the chamber.



- A - Photomultiplier Housing
- B - Photomultiplier Tube and Socket
- C - Upper Shutter Blade with ND2 Filter over One Aperture
- D - Lower Shutter Blade with Single Aperture
- E - Opal Diffuser Filter
- F - Aperture Disk
- G - Neutral Density Compensating (from set of 9)
- H - Lens 7 Diopter (2)
- J - Optical System Housing (2)
- K - Optical System Platform (2)
- L - Optical Windows
- M - Chamber Roof
- N - Alignment Rods (2)
- P - Parallel Light Beam 1.5 in (37.5 mm) Diameter
- Q - Chamber Floor
- R - Optical Window Heater, Silicone
- S - Regulated Light Source Transformer, 115/125 V-6 V
- T - Adjustable Resistor, Light Source Adjusted for 4V
- U - Light Source

Figure 6-8. Photometer Detail

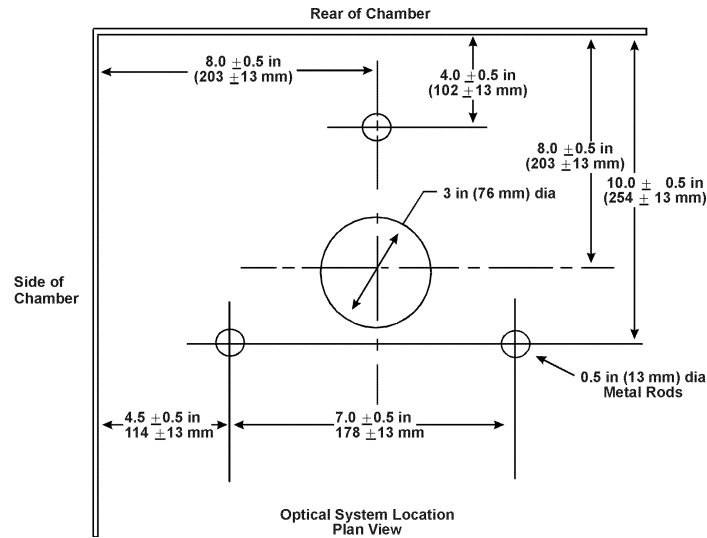


Figure 6-9. Photometer Location

6.3.1.11.2 Photomultiplier Tube

The photomultiplier tube will have an S-4 linear spectral response and a dark current less than 10^{-9} ampere.

6.3.1.11.2.1 The photomultiplier tube and associated optics will be mounted in a second lighttight box that is located above the chamber ceiling directly opposite the light source. The photomultiplier tube and its optics will be isolated from the chamber atmosphere by a glass window that is mounted flush with the chamber ceiling panel. The window, which permits viewing a cross section of 1.5 ± 0.13 inches (38 ± 3 mm), will be sealed to prevent leakage of chamber contents.

6.3.1.11.3 Microphotometer

The microphotometer will be capable of converting the signal from the photomultiplier tube to relative intensity and/or to optical density. The microphotometer/photomultiplier tube combination will be sensitive enough that the microphotometer can be adjusted to produce a full-scale reading (100 percent relative light intensity or optical density = 1) using the photomultiplier tube's response (output) to the light source when a filter of 0.5 or greater optical density is placed in the light path.

6.3.1.11.4 Alignment Fixture

The two optical windows and their housings will be kept in alignment and spaced 36 ± 0.125 inches (914 ± 3 mm) apart with an alignment fixture consisting of three metal rods 0.5 - 0.75 inch (13 - 19 mm) in diameter fastened securely to 0.31-inch (8-mm) -thick externally mounted top and bottom plates and symmetrically arranged about the collimated light beam.

6.3.1.11.5 Optical Filters

A set of nine neutral color optical filters of 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, and 0.9 optical density will also be provided. The optical filters, one or more as required, may be mounted in the light path in the optical measuring system to compensate for the sensitivity of the photomultiplier tube. These filters may also be used to adjust the photometric system as the light source and/or

photomultiplier tube change sensitivity through aging and/or as discoloration or deterioration of the optical windows occurs.

6.3.1.11.6 Recorder

A recording device will be furnished that provides a record of the percent light transmission and/or optical density versus time during the test. The record will consist either of a continuous curve on a chart recorder or discrete values taken at least every 5 seconds with a computerized data acquisition system.

6.3.1.12 Exhaust Hood

A method for removing the chamber contents after each test will be provided. A fitting for removing the chamber contents may be connected to a suitable exhaust hood. Locating an exhaust hood directly above the smoke chamber door is recommended as an additional safety device.

6.3.1.13 Conditioning Chamber

A conditioning chamber capable of maintaining test specimens at a temperature of $70^{\circ} \pm 5^{\circ}\text{F}$ ($21^{\circ} \pm 3^{\circ}\text{C}$) and $50\% \pm 5\%$ relative humidity will be provided.

6.4 Test Specimen Selection and Preparation

6.4.1 Specimen Number

A minimum of three specimens will be prepared and tested for each part/construction.

6.4.2 Specimen Selection

Specimens will either be taken from an actual part or built to simulate a part.

6.4.2.1 Flat sections of the same thickness and composition may be tested in place of curved, molded, or specialty parts.

6.4.2.2 Both faces of a multilayer assembly will be tested as a separate part/construction if the outer materials are different on the faces and if both sides are exposed to the passenger cabin interior. If both faces must be tested, two sets of specimens will be provided.

6.4.3 Specimen Size

Each specimen will be 2.9 ± 0.06 by 2.9 ± 0.06 inches (73 ± 2 by 73 ± 2 mm). The specimens will be the same thickness as the thickness of the part/construction.

6.4.4 Specimen Orientation

For materials that may have anisotropic flammability properties (i.e., different properties in different directions, such as machine and cross-machine directions for extrusions, warp and fill directions of a woven fabric, etc.), specimens will be tested in the orientation thought to give the highest result. If the average 4D_m is greater than 180, a second set of specimens will be prepared and tested in the orientation that is perpendicular to the orientation used for the first set of specimens. The higher of the two average 4D_m values will be reported.

6.4.5 Specimen Preparation

All surfaces of the specimen, except the surface to be exposed for the test, will be wrapped with aluminum foil (see section 6.3.1.9.4) prior to placing them in a specimen holder. The side of the foil with dull finish will be placed next to the specimen. After the specimen is placed in a specimen holder, any aluminum foil on the exposed specimen will be removed from the bottom (to avoid interference with the pilot burner flamelets) and either removed or folded back on the other three sides (to avoid covering any of the exposed specimen surface area). The specimen will be placed in a holder, followed by an alumina-silica backing board, the spring plate, and the retaining rod (see figure 6-6).

6.5 Specimen Conditioning

- 6.5.1 Specimens will be conditioned at a temperature of $70^{\circ} \pm 5^{\circ}\text{F}$ ($21^{\circ} \pm 3^{\circ}\text{C}$) and $50\% \pm 5\%$ relative humidity for a minimum of 24 hours unless otherwise specified. Only one specimen at a time will be removed from the conditioning chamber. When removed, the specimen will be immediately tested.

6.6 Test Chamber Calibration

6.6.1 Furnace Protection

Prepare a blank specimen consisting of 0.5-inch-thick alumina-silica millboard (see section 6.3.1.9.2) mounted in a specimen holder. To reduce problems with the stability of the heat flux density from the furnace, maintain the blank specimen in front of the furnace when no testing or calibration is being conducted.

6.6.2 Periodic Calibration Procedure

Conduct a periodic calibration of the system as follows.

6.6.2.1 Photometric System

The photometric system used in this test method is an inherently linear device. Check the system for proper photocell alignment. Verify, at least every 2 months, the linearity of the system using a set of neutral optical density filters or equivalent. If erratic behavior is observed or suspected, check the system more frequently.

6.6.2.2 Furnace

Use the approved heat flux density gauge to monitor the heat flux density produced by the furnace. Place the heat flux density gauge on the horizontal rods of the furnace support framework and accurately position it in front of the furnace opening by sliding and displacing the blank specimen holder against the spacing stop (see section 6.3.1.10). With the chamber door closed and the inlet vent opened, adjust the compressed air supply to the heat flux density gauge cooler to maintain its body temperature at $200^{\circ} \pm 50^{\circ}\text{F}$ ($93^{\circ} \pm 3^{\circ}\text{C}$). Adjust the setting of the furnace control voltage or power controller to obtain the calibrated millivolt output of the heat flux density gauge corresponding to a steady-state irradiance of $2.5 \pm 0.05 \text{ W/cm}^2$ ($2.2 \pm 0.04 \text{ Btu/ft}^2/\text{second}$). After the irradiance has reached the required value and has remained steady-state for at least 5 minutes, remove the heat flux density gauge from the chamber and replace it with the blank specimen holder.

- 6.6.2.2.1 Record the setting of the furnace control voltage or power controller and use this setting until a future calibration indicates it should be changed.

6.6.2.3 Chamber Leak Test

Test the smoke density chamber leak rate at least once a month, or more often if loss of chamber pressure is suspected, using the following procedure.

- 6.6.2.3.1 Close the inlet vent and the chamber door.

- 6.6.2.3.2 Pressurize (e.g., by bleeding in a small amount of air through the port used for the heat flux density gauge) the chamber to at least 3 inches of water above ambient as indicated by the manometer.

- 6.6.2.3.3 Note the chamber pressure. Verify that the chamber pressure leakage rate is less than 2 inches of water in 2 minutes.

6.6.2.4 Total System

Check the total system at least once a month by testing a material that has shown a consistent specimen-to-specimen 4D_m value in the range of 150 to 220 4D_m and that is, and will continue

to be, readily available. Maintain a record of the test results obtained. If erratic values are observed, identify and correct any instrumental or operational deficiencies.

6.6.3 Chamber Cleaning

Clean the optical system windows, viewing window, chamber walls, and specimen holders as follows.

6.6.3.1 Optical System Windows

Clean the exposed surfaces of the glass separating the photo detector and light source housings from the interior of the chamber after each test. Clean the top window first, then the bottom window, using a nonabrasive cloth dampened with a suitable cleaner. Dry the window to prevent streaking or film buildup. Do not use any cleaners that contain wax because wax will cause the smoke to adsorb to the glass more quickly.

6.6.3.2 Viewing Window

Clean the viewing window periodically as required to allow viewing the chamber interior during testing. The same cleaners used in section 6.6.3.1 have been found satisfactory.

6.6.3.3 Chamber Walls

Clean the chamber walls periodically to prevent excessive build-up of smoke products. An ammoniated spray detergent and nonabrasive scouring pad have been found effective.

6.6.3.4 Specimen Holders

Remove any charred residue on the specimen holders and horizontal rods securing the holder position to prevent contamination of subsequent specimens.

6.7 Test Procedure

6.7.1 Each day, prior to testing, adjust the chamber as follows.

6.7.1.1 Calibrate the furnace output according to section 6.6.2.2 to determine the correct furnace voltage.

6.7.1.2 Balance the photomultiplier dark current and set the clear beam reading to 100 percent relative transmission or to optical density 0.00.

6.7.1.3 Set the photomultiplier scale at 100. Shut the lower shutter blade (D) directly below photomultiplier tube (B) (see figure 6-8). Set zero on the data recording device.

6.7.2 Conduct the test procedure as follows.

6.7.2.1 Ensure that the specimen(s) have been properly prepared per sections 6.4.1 through 6.4.5.

6.7.2.2 Ensure that the chamber wall temperature is $95^{\circ} \pm 4^{\circ}\text{F}$ ($35^{\circ} \pm 2^{\circ}\text{C}$).

6.7.2.3 Ensure that the furnace voltage has been set correctly.

6.7.2.4 Set the clear beam reading to 100 percent relative transmission or to optical density 0.00. See section 6.7.1.2.

6.7.2.5 Position the pilot burner in front of and parallel to the specimen holder. Turn on the pilot burner fuel (see section 6.3.1.8) and light the flamelets on the pilot burner. Make sure all flamelets are ignited and properly adjusted.

6.7.2.6 Remove a test specimen from the conditioning chamber, open the test chamber door, and place the specimen holder on the support. Immediately push the specimen holder into position in front of the furnace, displacing the blank specimen holder to the prepositioned stop, and close the chamber door and inlet vent. For chambers with an external device to move the specimen holder in front of the furnace, place the holder on the support, close the

door, slide the sample into position, and simultaneously start the timer and recorder for light transmission.

- 6.7.2.7 Continue the test for a minimum of 4 minutes (240 seconds). Do not perform any analysis of the chamber contents, such as gas sampling, during the first 4 minutes (240 seconds) of testing.
- 6.7.2.8 Record the percent light transmission and/or optical density versus time (minutes) during the test.
- 6.7.2.9 Monitor the chamber pressure during the test. If negative pressure (below ambient atmospheric) develops, open the inlet valve slightly to relieve negative pressure.
- 6.7.2.10 Monitor the pilot burner flamelets during the test. Note and record if either of the outer flamelets oriented perpendicular to the specimen surface or if either of the inner flamelets oriented 45 degrees to the specimen surface extinguishes and remains continuously extinguished for more than 3 seconds. If such extinguishing occurs, the test results from that specimen are not valid, and the test may be terminated and another test started with a new test specimen.
- 6.7.2.11 At the termination of the test, remove the test specimen holder from its position in front of the furnace and replace it with the blank specimen holder using the exterior control rod. Begin exhausting the chamber of smoke within 1 minute by opening the door and the inlet vent (and exhaust vent, if used).
 - 6.7.2.11.1 Continue to exhaust the chamber until all smoke has been removed.
- 6.7.2.12 Clean the windows to the housings for the photomultiplier tube and the light source per section 6.6.3.1.
- 6.7.2.13 Calculate and record the maximum specific optical density, 4D_m , during the 4-minute (240-second) test for each specimen according to the formula:

$$\begin{aligned} {}^4D_m &= (V / LA) \log_{10}(100/{}^4T_m) \\ &= 132 \log_{10}(100/{}^4T_m) \end{aligned}$$

where:

- V = chamber volume = 18.00 ft³ (0.510 m³)
- L = light path length = 3.00 ft (0.914 m)
- A = exposed specimen area = 6.57 in² (0.00424 m²)
- 4T = minimum percent light transmission during 4 minutes
- $\log_{10}(100/{}^4T_m)$ = maximum optical density during 4 minutes

- 6.7.2.14 Calculate and record the average 4D_m value and its standard deviation for all the specimens tested for each part/construction. Use the actual 4D_m values for this average; do not use the average light transmission value to determine the average 4D_m value.

6.8 Report

- 6.8.1 Report a complete identification of the part/construction tested, such as material construction, thickness, weight, etc.
- 6.8.2 Report the number of specimens tested and the average 4D_m .
- 6.8.3 Report any additional data or observations as applicable and/or required by the test plan.

6.9 Requirements

- 6.9.1 Through FAR 25.853(c-1) Amendment 25-72, the average 4D_m during the 4-minute test will not exceed 200.

Chapter 6 Supplement

This supplement contains advisory material pertinent to referenced paragraphs.

6.2.1 In most cases, the maximum specific optical density (4D_m) should be at 4 minutes; however, due to coagulation of smoke particles, or to adsorption of smoke particles to the walls of the chamber, it is possible for the maximum to occur earlier in the test.

6.3.1 Recommended Equipment

The following items are recommended but not required:

- Digital Voltmeter—Preferred to monitor furnace voltage and heat flux density gauge output. A Keithley Model 165 Autoranging Multimeter or equivalent has been found acceptable.
- Constant Voltage Transformer—A constant voltage transformer is recommended for all installations (see section 6.3.1.5).
- Pilot Burner Positioning Fixture—A fixture to accurately position the pilot burner is recommended to establish a precise pilot burner position for testing and to facilitate accurate repositioning of pilot burner after removal and replacement (see figure 6-10).

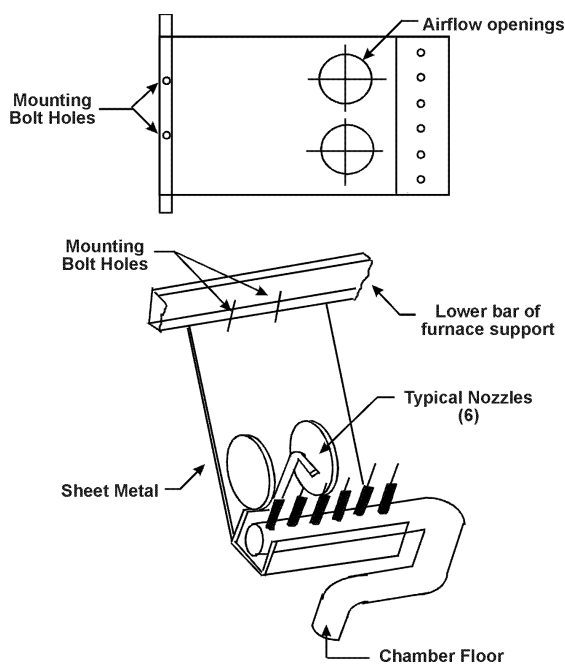


Figure 6-10. Burner Position (Optional)

A more precise positioning device is available from Newport Scientific. Its part number is 680860354000.

- Reignition System—A reignition system is recommended to relight the horizontal and 45-degree pilot burner flamelets to ensure that none of them extinguishes for more than 3 seconds during the test. The preferred method of reignition is a manually operated sliding tube, with a propane and air mix, adjusted to impinge on the pilot outlets as it is moved across an area adjacent to the pilot flames. A method of operating this could be made similar to the device in the smoke chamber that moves the sample, i.e., push-pull rod (see figure 6-4). If an electric sparking device is used, an appropriate method of suppression and equipment shielding must be applied to have no interference with the ability of the data acquisition equipment to accurately record data.

6.3.1.1 Commercially available panels of porcelain-enameled steel (interior surface) permanently laminated to a magnesia insulation core and backed with galvanized steel (exterior surface) have been found acceptable.

A thin sheet of transparent material may be placed over optical and viewing windows to protect them from corrosive components in the smoke.

6.3.1.3 Venting the water-filled pressure regulator to a suitable exhaust system is necessary to prevent the buildup of unknown contaminants in the laboratory area. The location of the pressure relief tube should be on or within 6 inches of the top of the chamber.

6.3.1.5 A powerstat variable autotransformer, Type 21, from Superior Electric Co., Bristol, Connecticut, or equivalent has been found satisfactory to transform electric power to that required by the chamber.

A constant voltage transformer from Sola Electric Co., Chicago, Illinois, Catalog Number 23-13-150, or equivalent, has been found satisfactory. A Sorenson Model 200S AC voltage regulator, or equivalent, has been found satisfactory.

6.3.1.6 Furnace model P/N 6806025700 from Newport Scientific has been found acceptable.

Furnace model P/N 680860380000 from Newport Scientific has also been found acceptable. A calibration device, P/N 4-5808, is also available from Newport Scientific.

6.3.1.6.3 A model 470 Series power controller manufactured by Eurotherm and a Model 3AEV1B10C1 Triac manufactured by General Electric Company, or equivalent, have been found satisfactory.

The furnace control system should be a reputable unit that provides the parameters to fulfill the requirements of the furnace.

It is recommended to use a digital voltmeter to monitor the furnace voltage output and a digital amperemeter to monitor the furnace current.

6.3.1.6.4 Gardon, R., "An Instrument for the Direct Measurement of Intense Thermal Radiation," *Review of Scientific Instruments*, Vol. 24, 1953, pp. 360-370.

A thermocouple system capable of measuring $200^{\circ} \pm 2^{\circ}\text{F}$ is an acceptable alternate method to monitor the body temperature of the heat flux density gauge.

6.3.1.7 The pilot burner should be aligned with a sample holder and backing board in place. A description of a suitable method of alignment is shown in figure 6-4. Care should be taken to ensure accurate positioning of the pilot tips to the sample holder.

6.3.1.8 Commercially bottled propane has been found acceptable.

6.3.1.9.1 Mounting the wire through holes made in the drip pan attachment mount between the top of the drip pan and the bottom of the holder across the face of the specimen and over the top of the holder, and through holes made in the flange of the top guide just above the top of the holder has been found satisfactory. This scheme permits the use of only one piece of wire threaded through the four holes with the two ends twisted together behind the guide at the top of the holder.

Sample holders must be checked for accuracy with each other; for example, top and bottom mounting devices consistent with each other. It has been noted that misalignment between holders does result in pilot position errors.

6.3.1.9.2 A recommended material is Marinite I.

6.3.1.9.4 Aluminum foil used for household food wrapping is acceptable.

6.3.1.11.2 A thin sheet of transparent material may be placed over optical and viewing windows to protect them from corrosive components in the smoke.

6.4.1 Conditions may require as many as six specimens. For test purposes, specimens should be marked with an arrow for a consistent direction by manufacturers or operators.

6.6.3.1 Ethyl alcohol, methyl ethyl ketone, or equivalent has been found satisfactory.

6.7.1.2 This procedure is described in AMINCO NBS Smoke Density Chamber, Catalog No. 4-5800B, Instruction 941B.

6.7.1.3 During testing at the FAA William J. Hughes Technical Center, a problem was discovered with the calculation of D_s during some NBS chamber testing. The problem is software related. It is possible that during the initial readings taken with a blanked off photocell there should be some residual voltage reading (± 1 millivolt). This is too small a value to be read visually but can be detected by the computer. The problem is that current software assumes the initial value is zero and the results are altered accordingly. Because the specific optical density is a logarithmic function, the problem is magnified by the higher the value, making the D_s around the pass/fail point of 200 critical. A \pm millivolt initial reading can change an actual D_s of 200 to 175/224, respectively. The fix for this problem is to blank off the photocell prior to each test and let the computer set the "zero."

Computer users could use the following procedure for the computer program: close the shutter, let the computer read baseline volts (0) (mV_b), and determine:

$$\text{Slope} = \frac{100}{(mV_H - mV_b)}$$
$$\%L.T. = (mV - mV_b) * \text{Slope}$$

6.7.2.11 CAUTION: The door should be opened gradually to avoid exposure to the chamber contents, which may be toxic.

Chapter 7

Oil Burner Test for Seat Cushions

7.1 Scope

- 7.1.1 This test method evaluates the burn resistance and weight loss characteristics of aircraft seat cushions when exposed to a high-intensity open flame to show compliance to the requirements of FAR 25.853.

7.2 Definitions

7.2.1 Burn Lengths

The four principal burn lengths are measured along the topside of the horizontal seat cushion, bottomside of the horizontal seat cushion, frontside of the vertical seat cushion, and the backside of the vertical seat cushion. The four burn lengths are defined as the distance measured, in inches, from the edge of the seat frame nearest the burner to the farthest point where damage to the test specimen occurred due to that area's combustion, including partial or complete consumption, charring, or embrittlement but does not include areas sooted, stained, warped, or discolored.

7.2.2 Percent Weight Loss

The percentage weight loss for a specimen set is the pretest weight of the specimen set less the posttest weight of the specimen set expressed as the percentage of the pretest weight. All droppings falling from the specimens and mounting stand are to be discarded prior to determining the posttest weight.

7.2.3 Back Cushion Specimen

The back cushion specimen is the cushion specimen in the vertical orientation. This specimen may be representative of the production seat back, seat bottom, or both if the production articles have the same construction.

7.2.4 Bottom Cushion Specimen

The bottom cushion specimen is the cushion specimen in the horizontal orientation. This specimen may be representative of the production seat back, seat bottom, or both if the production articles have the same construction.

7.2.5 Specimen Set

A specimen set consists of one back cushion specimen and one bottom cushion specimen. Both specimens represent the same production cushion construction; that is, both specimens in the specimen set have identical construction and materials proportioned to correspond to either the actual seat bottom or back cushion but not both. For various reasons seat bottom and back cushions on actual seats are typically as installed in the airplane.

7.3 Apparatus

7.3.1 Test Apparatus

The arrangement of the test apparatus is shown in figures 7-1 and 7-2 and includes the components described in this section. The burner stand has the capability of moving the burner away from the test specimen during warmup.

7.3.2 Test Burner

The burner will be a modified gun type, such as Park Model DPL 3400, Lennox Model OB-32, or Carlin Model 200 CRD. Flame characteristics can be enhanced by the optional use of a static disk or tabs. See static disk in the supplement to this chapter. Major deviations, for example a different burner

type, require thorough comparison testing. Temperature and heat flux measurements, as well as test results, must correspond to those produced by an FAA approved burner.

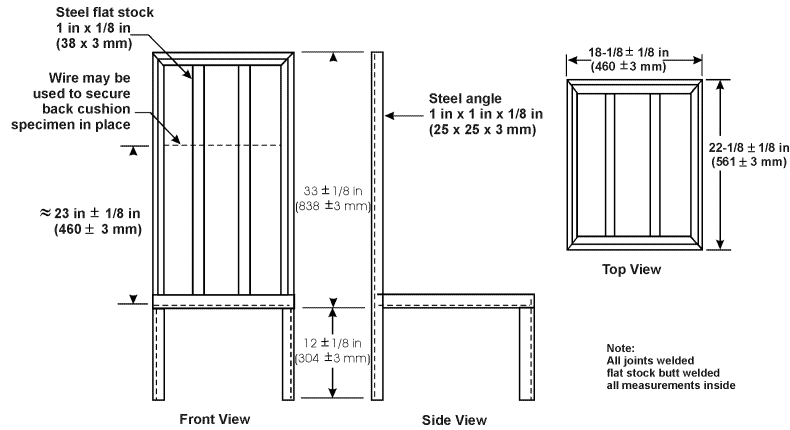


Figure 7-1. Front, Side, and Top Views of Seat Oil Burner Specimen Frame

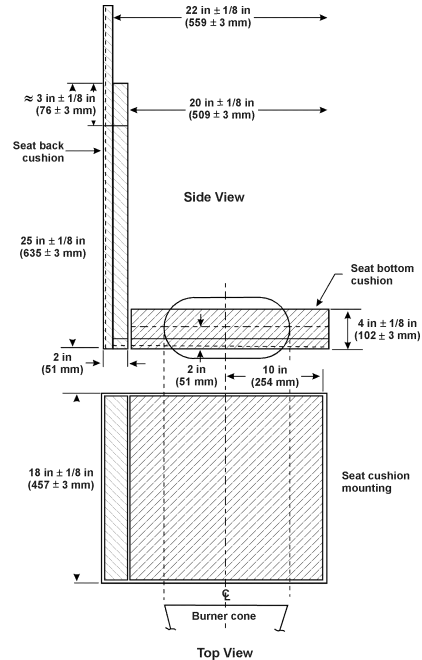


Figure 7-2. Top and Side View of Specimen Setup in Test Frame

7.3.2.1 Nozzle

The nozzle used for the burner is required to maintain a fuel pressure that will yield a 2 ± 0.1 gallons/hour ($0.126 \text{ L/min} \pm 0.0063 \text{ L/min}$) fuel flow.

7.3.2.2 Burner Cone

A $12 \pm 1/8$ -inch (305 ± 3 -mm) burner cone extension will be installed at the end of the draft tube. The cone will be made of stainless steel or a similar type of noncorrosive high-temperature metal and will have a thickness of 0.065 ± 0.015 inch (1.65 ± 0.375 mm). The opening of the cone will be $6 \pm 1/8$ inches (152 ± 6 mm) high and $11 \pm 1/8$ inches (280 ± 6 mm) wide (see cone in figures 7-3a and 7-3b).

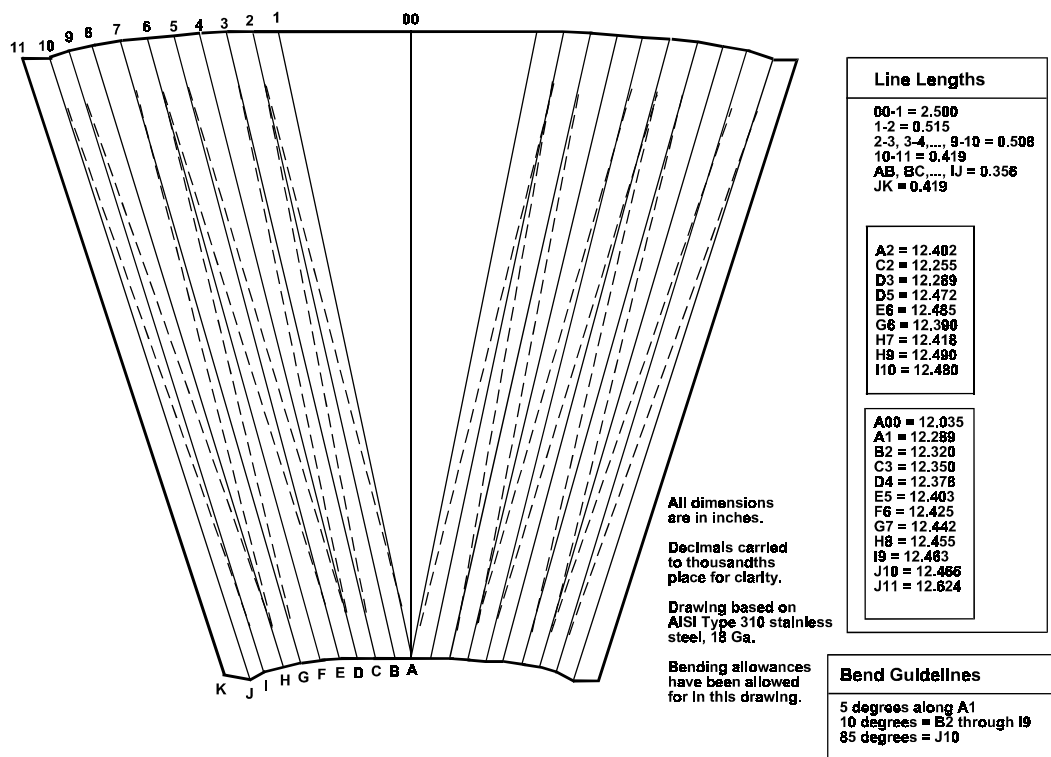


Figure 7-3a. Burner Cone Layout and Bending Pattern

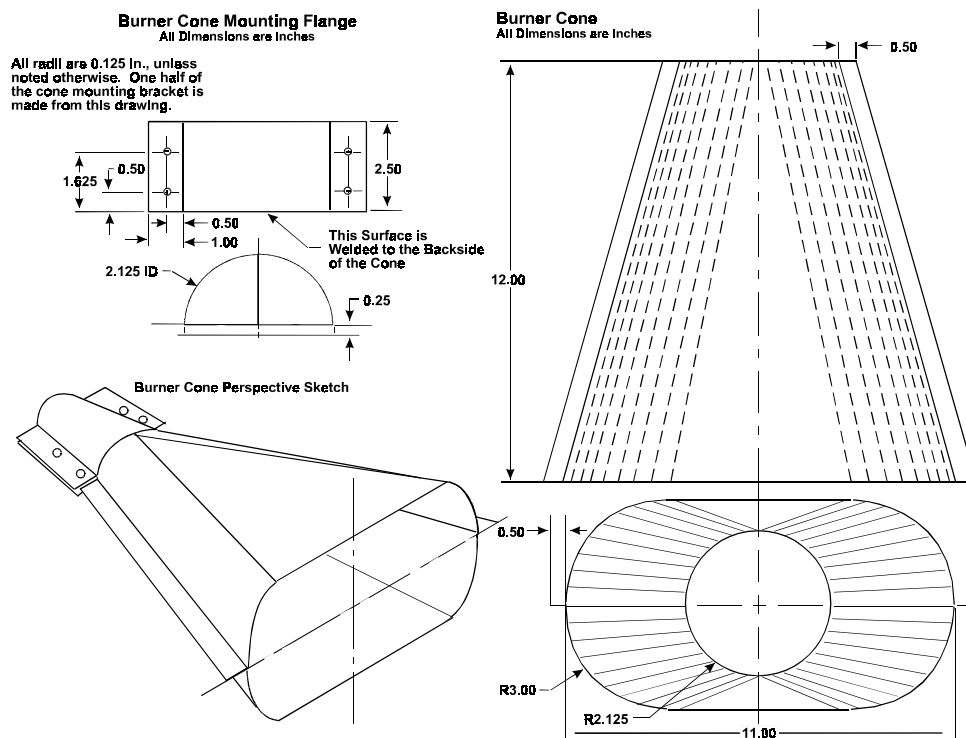


Figure 7-3b. Burner and Cone Details

7.3.2.3 Fuel

ASTM K2 fuel (number 2 grade kerosene) or ASTM D2 fuel (number 2 grade fuel oil) will be used.

7.3.2.4 Fuel Pressure Regulator

A fuel pressure regulator adjusted to deliver 2 gallons/hour \pm 0.1 gallon/hour (7.57 liters/hour \pm 0.038 liter/hour) will be provided.

7.3.2.5 Anemometer

A vane-type air velocity sensing unit will be used to monitor the flow of air at the inlet of the oil burner. The inlet will be completely sealed except for an opening for the air velocity sensor where it will be centered and mounted (see anemometer setup in figure 7-4).

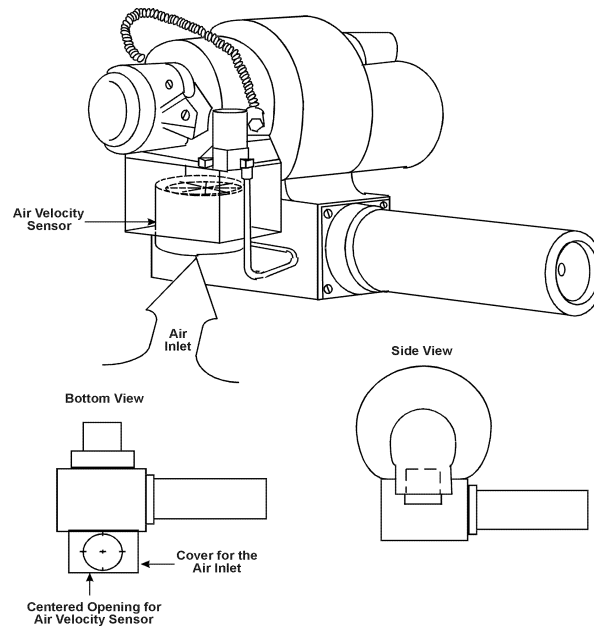


Figure 7-4. Illustration for the Location of the Air Velocity Sensor

7.3.3 Calorimeter

The calorimeter will be a total heat flux, foil type Gardon Gage of an appropriate range such as 0 to 15 Btu/(ft² second) (0 to 17 W/cm²), accurate to \pm 3 percent of the indicated reading.

7.3.3.1 Calorimeter Mounting

The calorimeter will be mounted in a 6 by 12 \pm 1/8-inch (152 by 305 \pm 3-mm) by 3/4-inch (19-mm) -thick insulating block that is attached to a steel angle bracket for placement in the test stand during burner calibration (see figure 7-5). The insulating block will be monitored for deterioration and replaced when necessary. The mounting will be shimmed as necessary to ensure that the calorimeter face is parallel to the exit plane of the test burner cone.

7.3.4 Thermocouples

Seven 1/16-inch-diameter ceramic packed, metal sheathed, type K (Chromelalumel), grounded junction thermocouples with a nominal 30 AWG size conductor will be provided for calibration. The thermocouples will be attached to a steel bracket to form a thermocouple rake for placement in the test stand during burner calibration, as shown in figure 7-6.

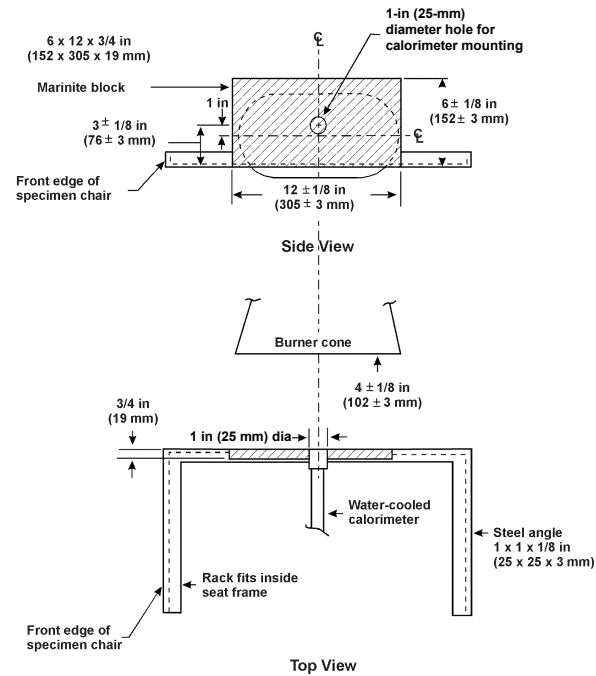


Figure 7-5. Top and Side Views of Calorimeter Bracket

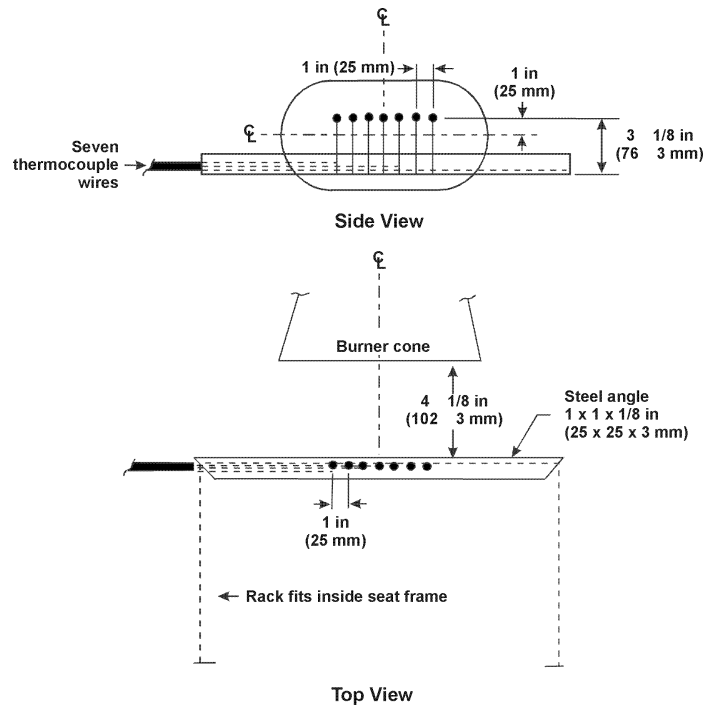


Figure 7-6. Top and Side Views of Thermocouple Rack Bracket

7.3.5 Specimen Mounting Frame

The mounting frame for the test specimen will be fabricated of 1 by 1 by 1/8-inch (25 × 25 × 3-mm) steel angle, as shown in figure 7-1. A wire can be added to the mounting frame for the seat back cushion to secure the specimen into place. The mounting stand will be used for mounting the test specimen seat bottom and seat back, as shown in figure 7-2. Reference paragraph 7.3.5 of Chapter 7 Supplement.

7.3.5.1 Drip Pan

The mounting stand will include a suitable drip pan lined with aluminum foil, dull side up. The drip pan will be located at the bottom of the mounting stand legs, $12 \pm 1/8$ inches (305 ± 3 mm) below the horizontal specimen holder.

7.3.6 Instrumentation

A calibrated recording device or a computerized data acquisition system with an appropriate range will be provided to measure and record the outputs of the calorimeter and the thermocouples.

7.3.7 Weight Scale

A weighing device will be provided to determine the pretest and posttest weights of each set of seat cushion specimens within 0.02 pound (9 g).

7.3.8 Timing Device

A stopwatch or other device, accurate to ± 1 second/hour, will be provided to measure the time of application of the burner flame and self-extinguishing time (or test duration).

7.4 Test Specimens

7.4.1 Specimen Preparation

A minimum of three specimen sets of the same construction and configuration will be prepared for testing.

7.4.2 Seat Bottom (Horizontal) Cushion Specimen

The constructed, finished specimen assembly will be $18 + 0, -1/8$ inches ($457 + 0, -3$ mm) by $20 + 0, -1/8$ inches ($508 + 0, -3$ mm) by $4 + 0, -1/8$ inches ($102 + 0, -3$ mm), exclusive of fabric closures and seam overlap.

7.4.3 Seat Back (Vertical) Cushion Specimen

The constructed, finished specimen assembly will be $18 + 0, -1/8$ inches ($457 + 0, -3$ mm) by $25 + 0, -1/8$ inches ($635 + 0, -3$ mm), by $2 + 0, -1/8$ inches ($51 + 0, -3$ mm), exclusive of fabric closures and seam overlap.

7.4.4 Construction

Each specimen tested will be fabricated using the principal components (i.e., foam core, flotation material, fire-blocking material, if used, and dress covering) and assembly processes (representative seams and closures) intended for use in the production articles. If a different material combination is used for the production back cushion than for the production bottom cushion, both material combinations will be tested as complete specimen sets. Each set will consist of a back cushion specimen and a bottom cushion specimen (see figure 7-7).

7.4.4.1 Fire-Blocking Material

If the cushion is constructed with a fire-blocking material, the fire-blocking material will completely enclose the cushion foam core material.

7.4.4.1.1 Specimen Fire-Blocking Fabrication

The method of fabricating blocking layer seams and closures will be the same as the production method. In fabricating the test specimen, the fire blocker will be configured so that any possible weak point is exposed to the burner flame. This may require configuring a test specimen so that the seam is exposed to the test burner, even though a seam may not be located there on a production cushion.

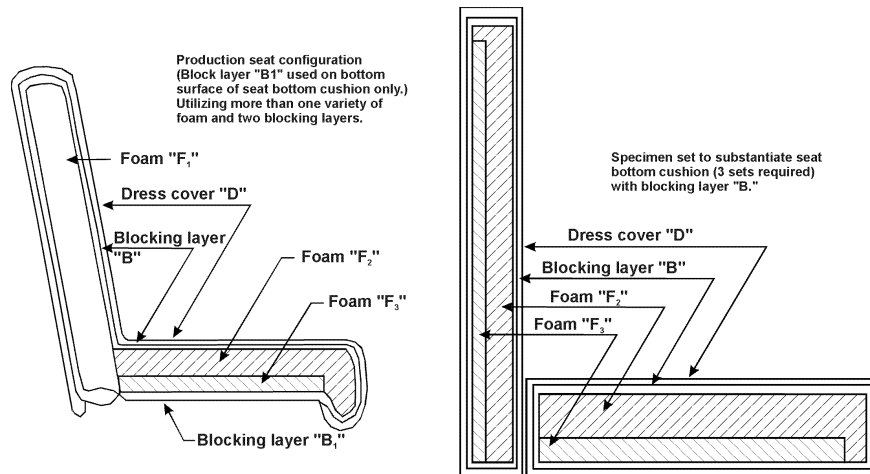


Figure 7-7. Example of Production Seat Configuration and Test Specimen Set to Substantiate Production Seat Bottom Cushion

7.4.4.1.2 Multiple Fire-Blocking Materials

If more than one fire-blocking layer material is used on a given production cushion, each blocking layer material will be subjected to this test procedure as separate test sets with the fire-blocking material completely encapsulating the specimens so that all fire-blocking layers are subjected to the same level of test severity. Fire-blocking layers will not be used in combination for this test (see figure 7-8).

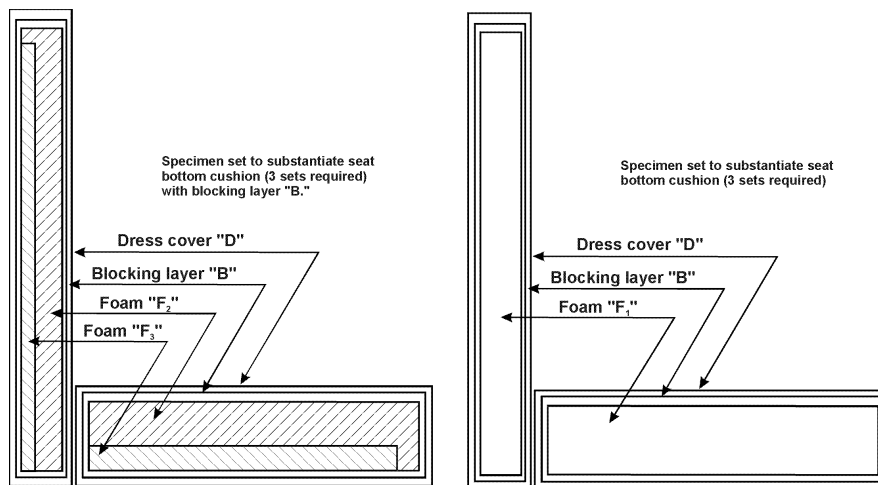


Figure 7-8. Specimen Set to Substantiate Production Seat Bottom and Specimen Set to Substantiate Production Seat Back

7.4.4.2 Foam

Seats that utilize more than one variety of foam (composition, density, etc.) will have specimen sets constructed that reflect the foam combination used.

7.4.4.3 Dress Covering

If a production seat construction utilizes more than one dress covering, the test configuration may be represented as shown in figure 7-9.

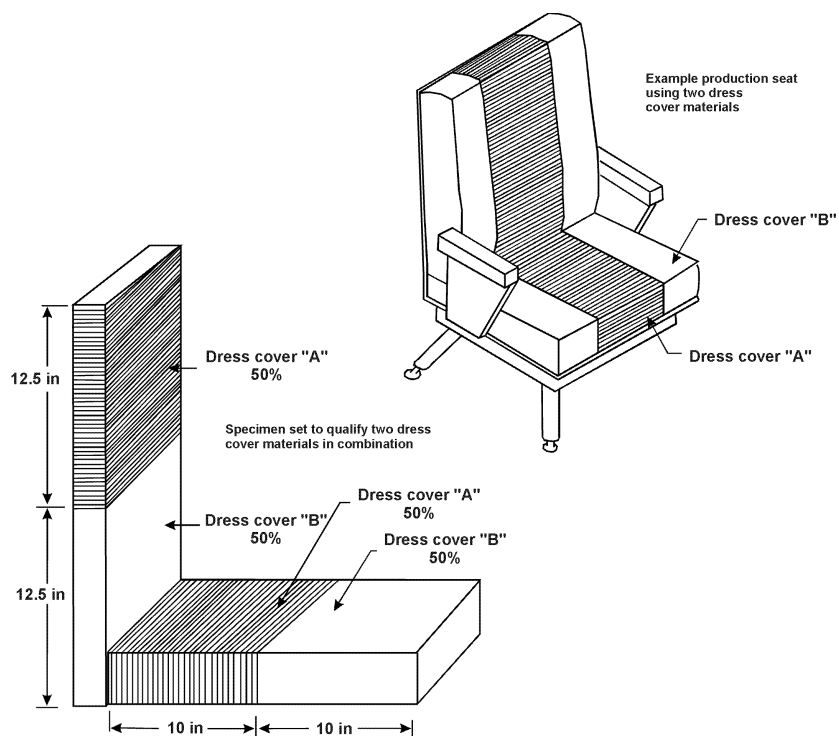


Figure 7-9. Example of Production Seat Configuration Using Two Dress Cover Materials and Test Specimen Set to Substantiate Dress Cover Combination

7.5 Specimen Conditioning

- 7.5.1 The specimens will be conditioned at $70^{\circ} \pm 5^{\circ}\text{F}$ ($21^{\circ} \pm 2^{\circ}\text{C}$) and $55\% \pm 10\%$ relative humidity for a minimum of 24 hours prior to testing.

7.6 Preparation of Apparatus

- 7.6.1 Level and center the frame assembly to ensure alignment of the calorimeter with the burner cone.
- 7.6.2 Turn on the ventilation hood for the test chamber. Do not turn on the burner fan. Measure the airflow in the test chamber using a hot wire anemometer or equivalent measuring device. The vertical air velocity just behind the top surface of the vertical specimen will be 25 ± 10 ft/min (12.7 ± 5.1 cm/second). The horizontal air velocity will be less than 10 ft/min (5.1 cm/second) just above the center of the horizontal seat cushion specimen.
- 7.6.3 The fuel flow rate will be 2.0 ± 0.1 gallon/hour (0.126 ± 0.0063 L/min).
- 7.6.4 The air inlet of the oil burner must be completely sealed, except for an opening where the air monitoring device will be mounted. With the anemometer set up for measuring, turn the motor on and run it for at least 30 seconds to allow the blower to reach its operating speed (it is not necessary for the ignitor and fuel flow to be turned on). Set the airflow to 67 ± 4 ft³/min (1.89 ± 0.11 m³/min) by adjusting the air shutter. (See paragraph 7.3.2.5 of Chapter 7 Supplements, for the airflow conversion formula and an example of airflow conversion based on an airflow of 67 cubic feet per minute.) Once this airflow value is maintained, keep the air shutter in position by tightening the lock screw. This will be the initial airflow setting. Later adjustments, within the specified airflow range, may be necessary to attain the calibration temperatures and heat flux.

7.7 Calibration

- 7.7.1 Secure the calorimeter in the bracket and place it on the test frame assembly used to mount specimens. Position the burner so that the vertical plane of the burner cone exit is centered in front of the test frame assembly at a distance of $4 \pm 1/8$ inches (102 ± 3 mm) from the calorimeter face. Ensure that the horizontal centerline of the calorimeter is offset $1 \pm 1/16$ inch (25.4 ± 1.6 mm) above the horizontal centerline of the burner cone (see figure 7-5).
- 7.7.1.1 Prior to starting the burner, ensure that the calorimeter face is clean of soot deposits and that there is water running through the calorimeter.
- 7.7.2 Rotate the burner from the test position to the warmup position. Examine and clean the burner cone of any evidence of buildup of products of combustion, soot, etc.
- 7.7.3 While the burner is rotated out of the test position, turn on the fuel and light the burner. Allow it to warmup for 2 minutes. Move the burner into the test position and adjust the air intake and oil burner components to achieve a heat flux of $10 \text{ Btu}/(\text{ft}^2 \text{ second} \pm 0.5 \text{ Btu}/\text{ft}^2/\text{sec})$ ($11.9 \text{ W}/\text{cm}^2 \pm 0.6 \text{ W}/\text{cm}^2$) or greater. Record heat flux density measurements at least once per second averaged over a 30-second time period to ensure a steady-state condition.
- 7.7.4 Replace the calorimeter bracket with the thermocouple rake, ensuring that the distance of each of the seven thermocouples is $4 \pm 1/8$ inches (102 ± 3 mm) from the vertical plane and offset $1 \pm 1/16$ inch (25.4 ± 1.6 mm) above the horizontal centerline of the burner cone exit (see figure 7-6).
- 7.7.5 Start the burner and allow it to warmup for 2 minutes. After warmup, move the burner into position and record the temperature of each thermocouple at least once every second averaged over a 30-second time period. Of the seven thermocouples used, any two will be equal to or greater than 1750°F (954°C), while the remaining thermocouples will each be equal to or greater than 1800°F (982°C). The average of the seven thermocouples must be equal to or greater than 1800°F . After a steady-state condition has been achieved with the required temperatures mentioned above, turn off the burner.
- NOTE: It is advisable to run within reasonable bounds of the heat flux and temperature requirements in sections 7.7.3 and 7.7.5. If the heat flux and temperature are significantly higher, erratic data may occur.
- 7.7.6 If the temperature of each thermocouple is not within the specified range, repeat sections 7.7.1 through 7.7.5 until all parameters are within the calibration.
- 7.7.7 When calibration is attained, tighten the air shutter's lock screw.

7.8 Test Procedure

- 7.8.1 Record the weight of each set of seat bottom and seat back cushion specimens to the nearest 0.02 pound (9 g's) and secure the test specimens to their respective frames. The seat back cushion can be secured at the top with wires. Reference paragraph 7.3.5 of Chapter 7 Supplement for guidance information.
- 7.8.2 Ensure that the vertical plane of the burner cone is at a distance of $4 \pm 1/8$ inches (102 ± 3 mm) from the test specimen and that the horizontal centerline of the burner cone is centered with the bottom cushion, as shown in figure 7-2.
- 7.8.3 When ready to begin the test, direct the burner away from the test position to the warmup position so that the flame will not impinge on the specimen. Turn on and light the burner and allow it to stabilize for 2 minutes.
- 7.8.4 To begin the test, rotate the burner into the test position and start the timing device when the burner is in the final position.
- 7.8.5 Expose the test specimen to the burner flame for 2 minutes and then turn off the burner. Immediately rotate the burner out of the test position.

- 7.8.6 Terminate the test when the specimens self-extinguish. If the specimens do not self-extinguish after 5 minutes from the time the burner had been turned off, terminate the test by extinguishing the test specimens.
- 7.8.7 Immediately after test termination, determine the posttest weight of the remains of the seat cushion specimen set to the nearest 0.02 pound (9 g's), excluding droppings.
- 7.8.8 Measure the four burn lengths. Reference paragraph 7.8.8 of Chapter 7 Supplement for help in determining burn length.

7.9 Report

- 7.9.1 Identify and describe the specimen being tested. Report the type of foam (flame retardant [FR] molded or cut); foam density, if known; and manufacturer and type of FR treatment if known.
- 7.9.2 Report the number of specimen sets tested.
- 7.9.3 Report the pretest and posttest weight of each set, the calculated percentage weight loss of each set, and the calculated average percentage weight for the total number of sets tested.
- 7.9.4 Report each of the four burn lengths for each set tested.

7.10 Requirements

- 7.10.1 For each of the burn lengths measured, the burn length may not exceed 17 inches (43.2 cm) on at least two-thirds of the total number of specimen sets tested. Additionally, the average burn length for each of the measured lengths will not exceed 17 inches.
- 7.10.2 The average percentage weight loss will not exceed 10 percent.
- 7.10.3 The weight loss of at least two-thirds of the total number of specimen sets tested will not exceed 10 percent.

Chapter 7 Supplement

This supplement contains advisory material pertinent to referenced paragraphs.

7.3.2.1 A Monarch 80°AR or 80°R nozzle nominally rated at 2.25 gal/hr (0.142 L/min) at 100 lb/in² (0.71 MPa) and operated at 85 lb/in² (0.6 MPa) gauge, has been found to deliver 2 gal/hr (0.126 L/min) and produce a proper spray pattern. A Monarch 80° Constant Capacity (CC) nozzle, nominally rated at 2 gal/hr at 100 lb/in² and operated between 95 and 105 lb/in² gauge is also acceptable. Minor deviations to the fuel nozzle spray angle, fuel pressure, or other similar parameters are acceptable if the fuel flow rate, temperatures, and heat flux measurements conform to the requirements of sections 7.6 and 7.7.

7.3.2.3 Number 2 diesel fuel, Jet A, or the international equivalent, is the recommended fuel because it has been found to produce satisfactory results if the fuel flow rate and inlet airflow conform to the requirements of sections 7.6 and 7.7.

7.3.2.4 A fuel pressure regulator that is adjusted to deliver 2 ± 0.1 gal/hr (0.126 ± 0.0063 L/min) flow through the nozzle should be provided. An operating fuel pressure of 85 ± 4 psig (0.57 ± 0.03 MPa) for a 2.25 gallons/hour (0.142 L/min) 80° spray angle nozzle has been found satisfactory.

7.3.2.5 The Omega microprocessor-based portable air velocity kit, model HH-30, is a suitable unit. The unit monitors air velocity in feet per minute (FPM) or meters per second (MPS) ± 1 percent reading accuracy, therefore, necessary conversions must be made to attain airflow values. To do this, the area of the opening of the air sensor must be measured. Once the area is found, install the air velocity sensor at the oil burner inlet. Following the procedures prescribed in section 7.6.4, this value should be multiplied by the air velocity reading. The Omega model HH-30 air velocity sensor's area is 0.037 ft². (For example, to achieve an airflow of 67 ft³/min, an air velocity reading of 1811 ft/min must be maintained.)

$$\text{Airflow} = \text{Air Velocity} \times \text{Area of Opening (Air Velocity Sensor)}$$

7.3.4 The thermocouples are periodically subjected to high temperatures during calibration. Because of this type of cycling, the thermocouples may degrade with time. Small but continuing decreases or extreme variations in temperature or “no” temperature reading at all are signs that the thermocouple or thermocouples are degrading or open circuits have occurred. In this case, the thermocouple or thermocouples should be replaced in order to maintain accuracy in calibrating the burner. It is recommended that a record for the amount of time the thermocouples are exposed to the oil burner's flame be kept.

7.3.5 A length of wire can be used to aid in securing the vertical seat cushion to the specimen frame (see figure 7-2). The wire should be uninsulated, solid, 0.032 inch (0.8 mm) or less in diameter and be located no more than 1/2 inch (13 mm) from the top surface of the vertical specimen as it sits in the frame. The wire should not disturb the flame spread behavior of the material(s) being tested. If the flame spread is affected, another wire configuration should be used.

7.3.7 A continuous weighing system is recommended as it allows the operator the ability to monitor weight loss during the test.

7.4.4.2 If, however, several seat models use similar foam combinations, it is not necessary to test each combination if it is possible to bracket the various combinations. For example, if foam “A” makes up 80 percent and foam “B” makes up 20 percent of the foam volume in one seat model and in another similar seat model, foam “A” makes up 20 percent and foam “B” makes up 80 percent of the foam volume, it is generally acceptable to approve all combinations of “A” and “B” foams between these limits if the 20/80 and 80/20 extremes are tested and pass. In addition, for foams of a given chemical composition, low-density foam can be used in lieu of foams of higher density. In this case, as in the case of foam combinations, all other elements that make up the cushion must be the same (see figure 7-7).

7.4.4.3 When any seat construction tested has passed, a separate test is not required for another seat construction if the only difference from the first test is the dress covering, provided the replacement dress covering is comprised of a similar weave design and fiber type, as described in section 7.4.4.3.2 and the burn length of the replacement dress covering, as determined by the Bunsen burner test specified in FAR 25.853(b), does not exceed the burn length of the dress covering used for the test.

Test specimens are intended to represent the principal material elements and construction methods of the production seats. Items decorative in nature, such as buttons, detail stitching, hand-hold straps, velcro attached strips, or thin outer cover paddings, such as armrest covers and filler around food trays, that do not penetrate the fire-blocking layer when fastened are not required to be represented on the test specimen. Dress cover details and items not associated with the cushion construction, such as metal seat pans or other metal structures, should not be included in the specimen weight since they are not part of the principal seat construction. Layers of padding or filler immediately under the dress cover material are considered to be part of the dress cover material and should be included in the test specimens.

Similar dress covering (from Advisory Circular 25.853-1, “Flammability of Aircraft Seat Cushions,” Sections 5d[1] and [2]) refers to dress covering materials having the same material composition, weave style, and weight. Material blends can be considered similar when the constituent materials fractions are the same, ± 6 percent, as the tested material. Examples of different weave styles include plain, jacquard, or velvet. With regard to weight, lighter fabrics are generally more critical than heavier fabrics. Due to the severe shrinking and unpredictable distortion experienced by leather dress cover materials, similarity approvals for leather are not recommended.

Certification by similarity to previously tested dress covers should be limited to instances where the material composition is the same and the weight and weave type are essentially the same. In all cases, results of the Bunsen burner test per FAR 25.853(b) for the new material should be equal to or better with respect to burn length than the tested material. In addition, it may be useful to evaluate the weight loss and burn length results of the oil burner test to determine if the tested material is a good basis for similarity; that is, the closer weight loss and burn length with the oil burner are to the maximum allowed, the more alike the dress covering materials should be for similarity. In general, test data and resultant experience gained from conducting tests should also be a major source of information to determine if approval by similarity is acceptable.

7.6.2 The language of paragraph 7.6.2 in the handbook can be met by measuring the vertical air flow at four points. These points are located behind the vertical specimen, 1/2 inch (113 mm) from the rear-facing vertical surface, 2 inches (305 mm) below the vertical specimen top surface, 2 inches (305 mm) above the vertical specimen bottom surface, and horizontally positioned 6 inches (152 mm) from each side. The measurements do not need to be made simultaneously, precluding the need for multiple anemometers. However, these measurements should be made in the same calibration cycle. The horizontal air velocity can be measured 1/2 inch (13 mm) above the geometric center of the upper horizontal surface.

7.6.3 If this measurement method is used to determine the fuel flow rate, the person(s) performing the measurement should realize that flammable vapors should be present in the test chamber. Caution must be exercised during the measurement period to avoid all possible ignition dangers.

If a calibrated flow meter is not available, measure the fuel flow rate using a 300 to 500 millimeter graduated cylinder or beaker, a 1/2 inch (13 mm) or large diameter rubber or plastic drain tube, and a timer.

There are two items that need consideration because they can affect the measurement accuracy. First, if a tube of insufficient diameter is used, conduit flow in the tube should add an additional back pressure to the nozzle flow. Second, when reading the collection vessel to determine the fuel volume delivered by the nozzle, ensure that the vessel is level and the fluid level is measured by reading the height of the meniscus. If either of these items is not considered, grave errors in fuel flow measurement can result.

The directions for finding the fuel flow rate follow. Remove the oil burner draft tube. Place the drain tube over the nozzle orifice. Drape the tube into the collection vessel, which is at a level lower than the nozzle. Ensure that the

ignitor system is turned off, then turn on the fuel pump and burner motor. Collect the fuel in the graduated cylinder or beaker for a 2-minute period. Measure the fuel volume delivered and calculate the fuel flow rate.

$$2 \text{ gallons/hour} = 126 \text{ millimeters/minute}$$

7.7 Static disks were recently developed to stabilize the air before entering the combustion area. Two were designed by Park Oil Burner Manufacturing Company of Atlantic City, New Jersey. The Park Oil Burner disks are both made of steel. See figure 7-10 for details on disks. Disks 1 and 2 are made for easy assembly, only requiring the removal of the draft tube and installation of the disk. Disk 3 was developed by CEAT, the French Ministry of Defense. The disk is made of a Nomex honeycomb material. CEAT uses two honeycomb disks positioned behind the stabilizer.

These disks are an optional feature and are used (any one or more of the three) to help produce a more full and even flame pattern. However, there is no guarantee of achieving calibration using a disk with all of the various makes and models of burners used throughout the industry.

7.7.1.1 Operating the calorimeter without water running through it could permanently damage the calorimeter.

7.7.2 A stainless steel wire brush is one possible cleaning tool. Soot buildup inside the burner cone can affect the flame characteristics and cause calibration difficulties. Since the burner cone may distort with time, dimensions will need to be checked periodically.

7.7.7 Calibrate the burner prior to each test until consistency has been demonstrated. After consistency has been confirmed, several tests can be conducted with calibration before and after each series of tests.

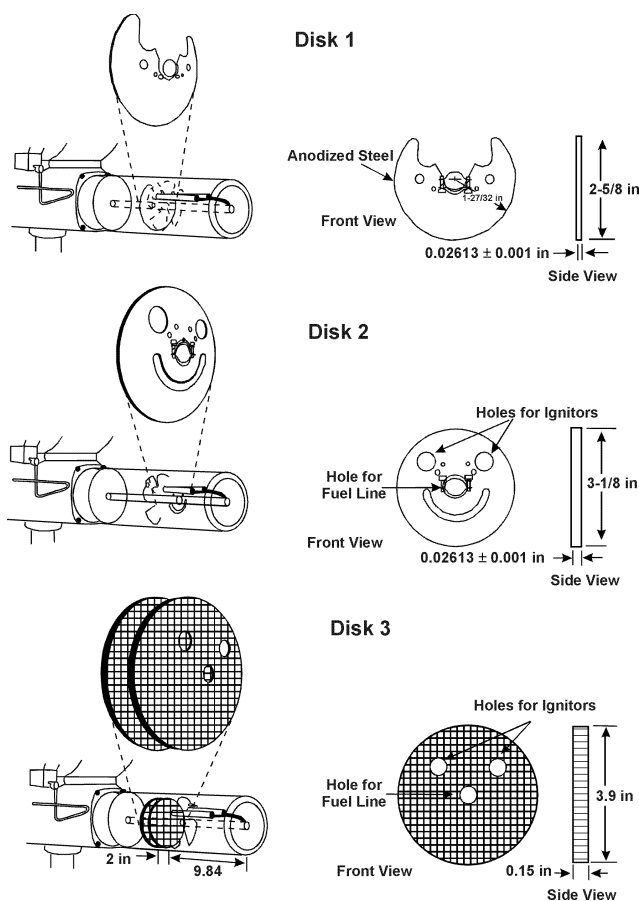


Figure 7-10. Static Disk Illustration

Recommendations for achieving calibration temperatures:

1. Set the stabilizer 3.25 ± 0.25 inches from the end of the draft tube.
2. Rotate the ignitor to the 6 o'clock and 9 o'clock position (viewpoint: looking toward the stabilizer from the end of the draft tube).
3. Seal all possible air leaks around the burner cone and draft tube area.
4. Use static disk to improve flame characteristics. See figure 7.9 for information on disks.

7.8.8 An industry practice acceptable to the FAA for determining specimen damage length, in order to measure burn length, has been to use an object with a dull point, such as a pencil, and scrape the dress covering. If the object used penetrates the dress covering, damage has occurred due to that area's combustion. If the dress covering is not penetrated, damage has occurred due to pyrolysis and is not considered damaged by combustion.

Chapter 8

Oil Burner Test for Cargo Liners

8.1 Scope

- 8.1.1 This test method evaluates the flame penetration resistance capabilities of aircraft cargo compartment lining materials utilizing a high-intensity open flame to show compliance to the requirements of FAR 25.855.

8.2 Definitions

8.2.1 Burnthrough

Burnthrough is defined as flame penetration of the test specimen.

8.2.2 Specimen Set

A specimen set consists of three or more replicates of a ceiling and sidewall cargo liner panel installation.

8.3 Apparatus

8.3.1 Test Specimen Frame

The test specimen frame is shown in figures 8-1 through 8-3. The burner will be mounted on a swiveling device capable of allowing it to be directed away from the test specimen during warmup.

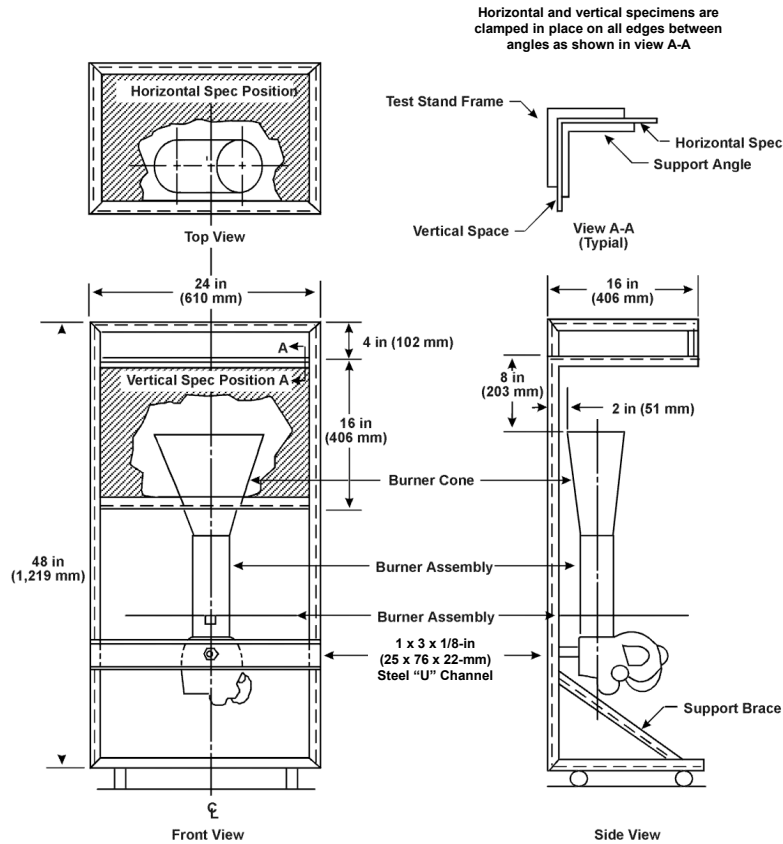


Figure 8-1. Test Apparatus for Horizontal and Vertical Mounting for Cargo Liner Oil Burner Testing

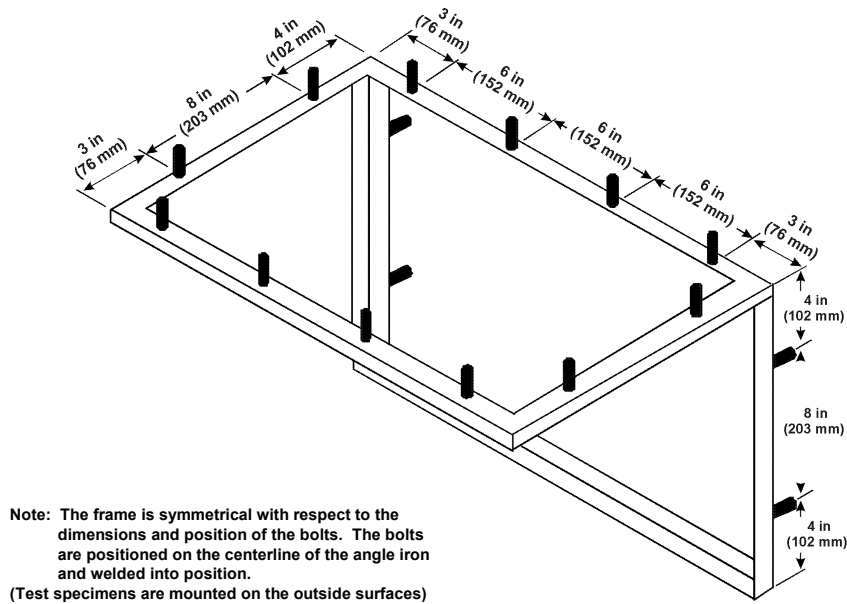


Figure 8-2. Cargo Liner Test Specimen Frame

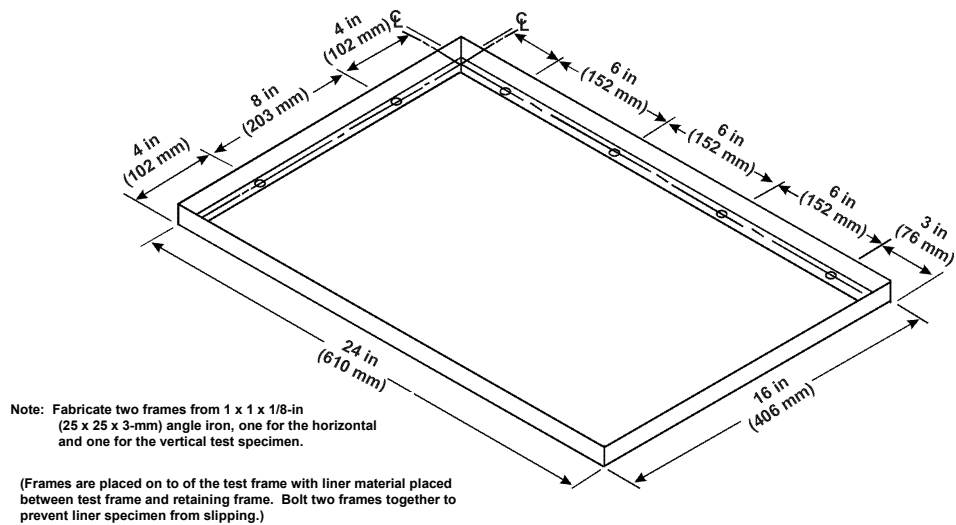


Figure 8-3. Cargo Liner Test Specimen Retaining Frame

8.3.2 Test Burner

The burner will be a modified gun type, such as Park Model DPL 3400, Lennox Model OB-32, or Carlin Model 200 CRD. Flame characteristics can be enhanced by the optional use of a static disk or tabs. Major deviations, such as a different burner type, should have thorough comparison testing. Temperature and heat flux measurements, as well as test results, must correspond to those produced by an FAA approved burner.

8.3.2.1 Nozzle

A nozzle will be provided to maintain the fuel pressure to yield a nominal 2 ± 0.1 gal/hr (0.126 ± 0.0063 liter/min) fuel flow (see Chapter 8 Supplement).

8.3.2.2 Burner Cone

A $12 \pm 1/8$ -inch (305 ± 3 -mm) burner cone will be installed at the end of the draft tube. The cone will be made of stainless steel or a similar type of noncorrosive high-temperature metal and will have a thickness of 0.065 ± 0.015 inch (1.65 ± 0.375 mm). The opening of the cone will be $6 \pm 1/4$ inches (152 ± 6 mm) high and $11 \pm 1/4$ inches (280 ± 6 mm) wide (see figures 8-4a and 8-4b).

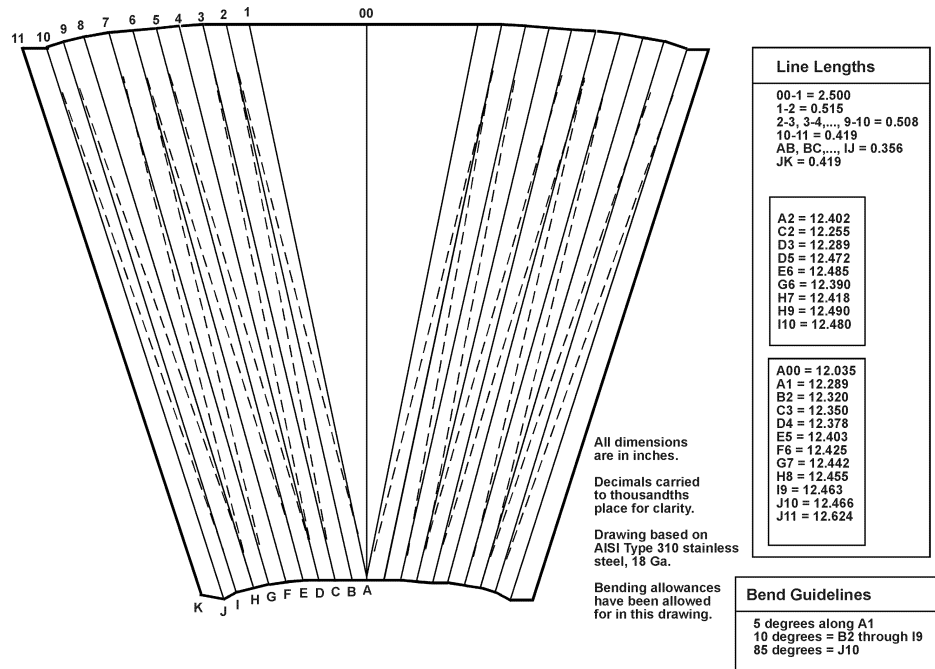


Figure 8-4a. Burner Cone Layout and Bending Pattern

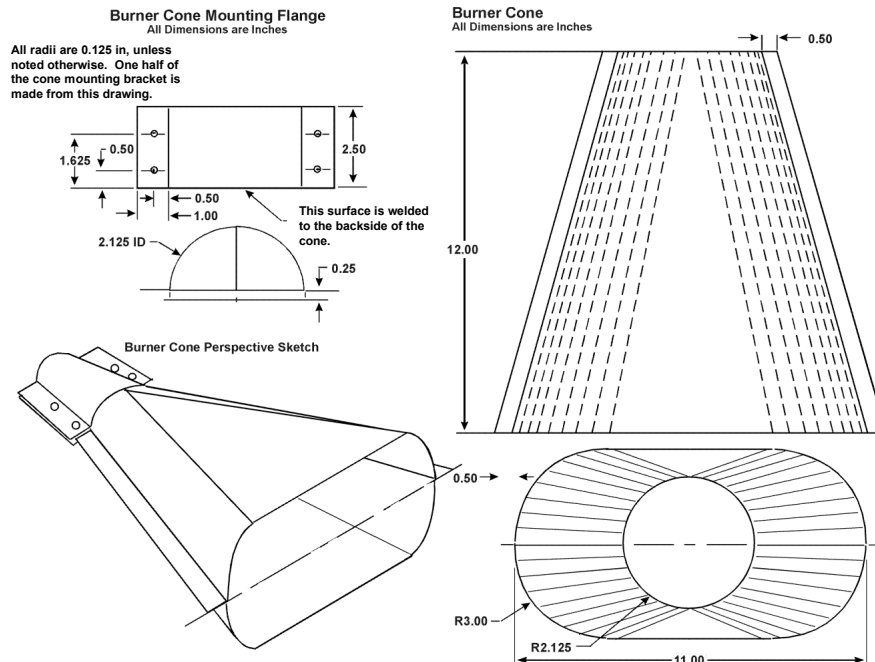


Figure 8-4b. Burner Cone Details

8.3.2.3 Fuel Pressure Regulator

A fuel pressure regulator, adjusted to deliver 2 gal/hr \pm 0.1 gal/hr (0.126 liter/min), will be provided (see Chapter 8 Supplement).

8.3.2.4 Fuel

Either number 2 Grade kerosene or American Society for Testing and Materials (ASTM) D2 fuel (number 2 Grade fuel oil) will be used.

8.3.2.5 Burner Airflow

Adjust the shutter to attain an airflow of 67 ± 4 ft³/min (1.89 ± 0.011 m³/min). See paragraph 8.3.5.2 of Chapter 8 Supplement.

8.3.3 Calorimeter

The calorimeter will be a total heat flux density, foil type Gardon Gauge of an appropriate range, such as 0-15 Btu/(ft² second) (0-17 W/cm²), accurate to \pm 3 percent of the indicated reading.

8.3.3.1 Calorimeter Mounting

The calorimeter will be mounted in a 6 by 12 \pm 1/8-inch (152 by 305 \pm 3-mm) by 3/4-inch (19-mm) -thick insulating block that is attached to a steel angle bracket for placement in the test stand during burner calibration (see figure 8-5). The insulating block will be monitored for deterioration and the mounting shimmed as necessary to ensure that the calorimeter face is parallel to the exit plane of the test burner cone.

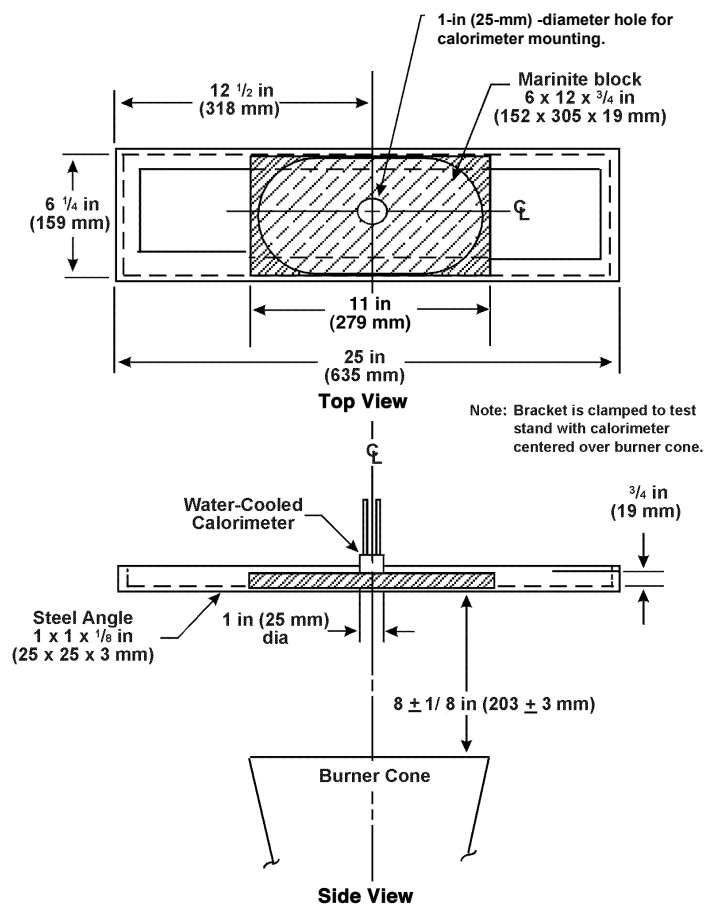


Figure 8-5. Top and Side Views of Calorimeter Bracket

8.3.4 Thermocouples

The seven thermocouples to be used for calibration will be 1/16-inch (1-mm) ceramic packed, metal sheathed, type K (Chromel-Alumel), grounded junction thermocouples with a nominal 30 AWG size conductor. The seven thermocouples will be attached to a steel angle bracket to form a thermocouple rake for placement in the test stand during burner calibration, as shown in figure 8-6.

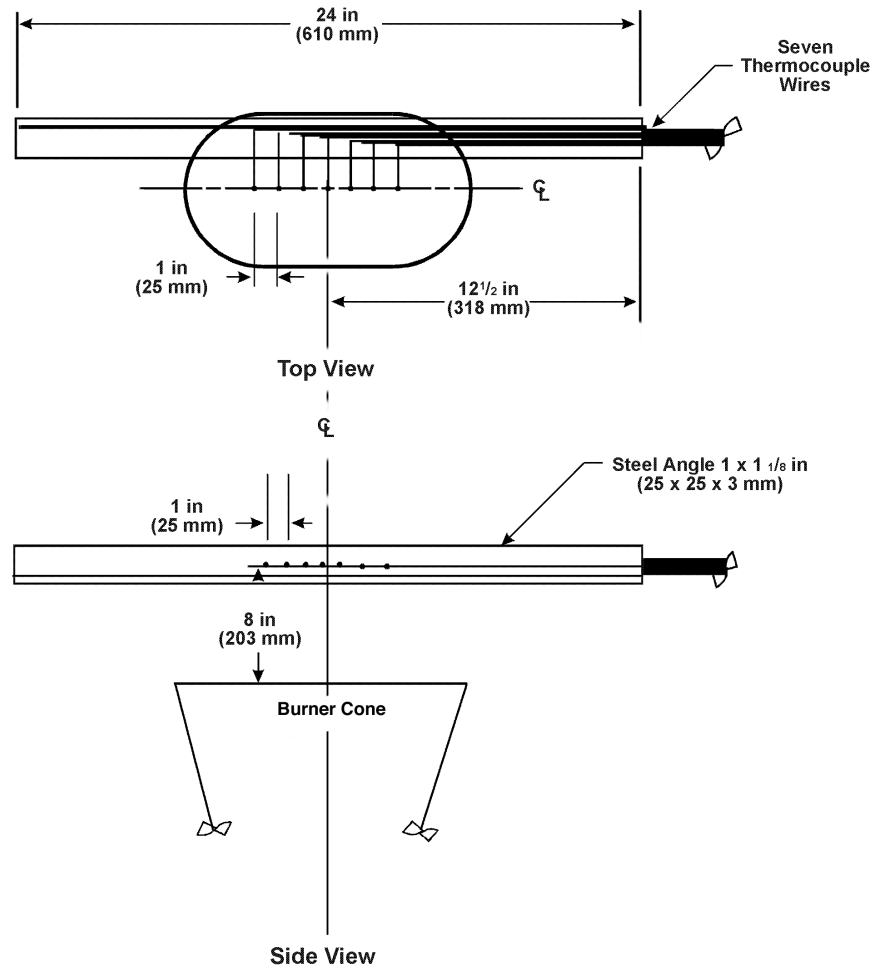


Figure 8-6. Top and Side View of Thermocouple Rake Bracket

8.3.5 Instrumentation

A calibrated recording device or a computerized data acquisition system with an appropriate range will be provided to measure and record the outputs of the calorimeter and the thermocouples.

8.3.5.1 Timing Device

A stopwatch or other device, accurate to within 1 second/hour, will be provided to measure the time of application of the burner flame, the material flaming time, and the burnthrough time.

8.3.5.2 Anemometer

A vane-type air velocity sensing unit will be used to monitor the flow of air at the inlet of the oil burner. The inlet will be completely sealed except for an opening for the air velocity

sensor where the inlet will be centered and mounted. See the anemometer setup in figure 8-7.

8.4 Test Specimen(s)

8.4.1 Specimen Configuration

Each cargo liner panel type and design configuration will be tested. Design configuration includes cargo compartment design features such as corners, joints, seams, lamp assemblies, pressure relief valves, temperature sensors, etc., that may affect the capability of a cargo compartment to safely contain a fire.

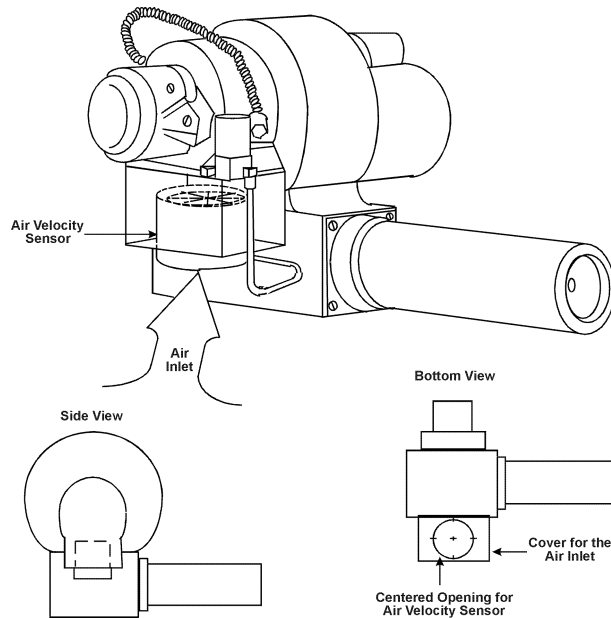


Figure 8-7. Illustration for the Location of the Air Velocity Sensor

8.4.1.1 Ceiling and sidewall liner panels may be tested individually provided a baffle of fire-resistant material, such as Kaowool or Marinite, is used to simulate the missing panel.

8.4.2 Specimen Number

A minimum of three specimens or specimen sets for each panel type or design configuration will be prepared for testing.

8.4.3 Specimen Size

The specimens to be tested will measure $16 \pm 1/8$ inches (406 ± 3 mm) by $24 \pm 1/8$ inches (610 ± 3 mm).

8.5 Specimen Conditioning

8.5.1 The specimens will be conditioned at $70^\circ \pm 5^\circ\text{F}$ ($21^\circ \pm 2^\circ\text{C}$) and $55\% \pm 10\%$ relative humidity for a minimum of 24 hours prior to testing.

8.6 Preparation of Apparatus

8.6.1 The air inlet of the oil burner must be completely sealed except for an opening where the air monitoring device will be placed. With the anemometer setup for measuring, turn the motor on and run it for at least 30 seconds to allow the blower to reach its operating speed (it is not necessary for the ignitor and fuel flow to be turned on). Set the airflow to 67 ± 4 ft³/min (1.89 ± 0.011 m³/min) by adjusting the air

shutter (see paragraph 8.3.5.2 of Chapter 8 Supplement for airflow conversion). Once this airflow value is attained, keep the air shutter in position by tightening the lock screw. This will be the initial airflow setting. Later adjustments may be necessary to reach calibration temperatures and heat flux within the specified airflow range.

- 8.6.2 If a calibrated flow meter is not available, measure the fuel flow using a graduated cylinder of appropriate size. Turn on the fuel pump and the burner motor, making sure the igniter system is off. Collect the fuel by placing a plastic or rubber tube into the graduated cylinder for a 2-minute period. Ensure that the flow rate is 2 ± 0.1 gal/hr (0.126 ± 0.0063 L/min).

8.7 Calibration

- 8.7.1 Secure the calorimeter in its bracket and place it on the specimen mounting test frame, making sure it is centered over the burner cone at a distance of $8 \pm 1/8$ inches (203 ± 3 mm) from the exit of the burner cone, as shown in figure 8-5. Ensure that the burner is in the proper position relative to the specimen mounting frame, $2 \pm 1/8$ inches (51 ± 3 mm) from the sidewall panel frame. Position the center of the calorimeter over the center of the burner cone.
- 8.7.2 Prior to starting the burner, ensure that the calorimeter face is free of soot deposits and that there is water running through the calorimeter.

CAUTION! Exposing the calorimeter to the burner flame without water running through it will destroy the calorimeter.

- 8.7.3 Rotate the burner from the test position to the warmup position. Examine and clean the burner cone of any evidence of buildup of products of combustion, soot, etc.
- 8.7.4 While the burner is in warmup position, turn on the fuel flow and light the burner. Allow it to warmup for at least 2 minutes. Move the burner into test position and adjust the air intake to produce a heat flux density of 7.5 Btu/(ft² second) (8.6 W/cm²) or greater. Record the heat flux density measurements at least once per second averaged over a 30-second time period to ensure that steady-state conditions have been achieved. After steady-state conditions have been achieved, turn the burner off.
- 8.7.5 Replace the calorimeter bracket with the thermocouple rake. Check the distance of each of the seven thermocouples to ensure that they are located $8 \pm 1/8$ inches (203 ± 3 mm) from the horizontal plane of the burner exit. Place the center thermocouple (thermocouple number 4) over the center of the burner cone exit (see figure 8-6).
- 8.7.6 Turn on the burner and allow it to warm up for at least 2 minutes. After warmup, record the temperature of the thermocouples at least once per second averaged over a 30-second time period. The temperature of each thermocouple will be 1600°F (871°C) or greater.
- 8.7.7 If the temperature of each thermocouple is not within the specified range, repeat sections 8.7.1 through 8.7.3 until all parameters are within the calibration range. When required thermocouple temperatures have been achieved, check that the airflow is within the required range. Once the parameters are within the specified range, secure the air shutter by tightening the lock screw.
- 8.7.8 Calibrate prior to each test until consistency (heat flux and temperature remaining within calibration tolerance) has been demonstrated. After consistency has been confirmed, several tests can be performed with calibration conducted before and after the tests. See this chapter's supplement for recommendations on achieving calibration.

8.8 Procedure

- 8.8.1 Examine and clean the cone of soot deposits and debris.
- 8.8.2 Mount the sidewall and/or ceiling cargo liner specimen(s) on the respective frame(s) and secure to the test frame(s) using the retaining frame(s). Bolt the retaining frame(s) and the test frame(s) together. Verify that the horizontal test frame is level.

- 8.8.3 Mount the thermocouple or thermocouple rake $4 \pm 1/8$ inches (102 ± 3 mm) above the horizontal ceiling panel test specimen. If the thermocouple rake is being used, position the center thermocouple (thermocouple number 4) over the center of the burner cone exit.
- 8.8.4 Move the burner into warmup position so that the flame does not impinge on the test specimen during the warmup period. Turn on the burner and allow it to stabilize for at least 2 minutes.
- 8.8.5 Move the burner into test position, then start the timing device.
- 8.8.6 Record the temperature of the thermocouple (thermocouple number 4, if using the thermocouple rake also used for calibration) at least once a second for the duration of the test.
- 8.8.7 Expose the specimen to the flame for 5 minutes or until flame penetration occurs.
- 8.8.8 The following sections present testing procedures for patch repairs, seams, joints, fastening systems, lighting fixtures, and corners.
 - 8.8.8.1 Patch Repairs
See Chapter 15 for instructions.
 - 8.8.8.2 Seams, Joints, Fastening Systems, Lighting Fixtures, and Corners
The barrier material used for design features such as recessed lighting fixtures and pressure relief valves will be tested in the same manner as a cargo liner specimen. Seams, joints, and fasteners in the ceiling position will be tested longitudinally extending the length of the liner and centered over the burner cone. Seams or joints used on the sidewall will be positioned 2 inches from the top of the liner longitudinally as representative of the aircraft application. Apply the test procedures in sections 8.8.1 through 8.8.8 to test these design features.
- 8.8.9 Turn off the burner to terminate the test.

8.9 Report

- 8.9.1 Report a complete description of the material(s) being tested, including manufacturer, thickness, etc.
- 8.9.2 Report the orientation of the panels tested (i.e., ceiling and/or sidewall).
- 8.9.3 Record any observations regarding the behavior of the test specimen during flame exposure, such as delamination, resin ignition, smoke, etc., and the time each event occurred.
- 8.9.4 Report the time of occurrence of flame penetration, if applicable, for each of the three specimens tested.
- 8.9.5 If flame penetration does not occur, report the maximum backside temperature and time of occurrence.
- 8.9.6 Provide a record of calibration.

8.10 Requirements

- 8.10.1 None of the three specimens tested will burn through within the 5-minute flame exposure.
- 8.10.2 Each of the three specimens tested will not exceed 400°F at the backside temperature monitored during flame exposure.
- 8.10.3 Specimens that pass in the ceiling orientation may be used as a sidewall panel without further test.
- 8.10.4 For the patch adhesion test, the patch must be intact after the 5-minute flame exposure.

Chapter 8 Supplement

This supplement contains advisory material pertinent to referenced paragraphs.

8.3.2 The basic burner and the use of tabs are described in FAA Powerplant Engineering Report No. 3A, "Standard Fire Test Apparatus and Procedure for Flexible Hose Assemblies," dated March 1978, and Report No. DOT/FAA/RD/76/213, "Re-evaluation of Burner Characteristics for Fire Resistant Tests," dated January 1977. The test settings specified in this specification, however, differ from those specified in the above reports.

8.3.2.1 A Monarch 80-degree AR or 80°R nozzle, nominally rated at 2.25 gal/hr (0.142 L/min) at 100 lb/in² (0.69 MPa) and operated at 85 lb/in² (0.59 MPa) gauge, has been found satisfactory to maintain a fuel flow of 2 gal/hr (0.126 L/min) and produce a proper spray pattern. A Monarch 80-degree CC nozzle, nominally rated at 2 gal/hr at 100 lb/in² and operated between 95 and 105 lb/in² gauge, is also acceptable. Minor deviations to the fuel nozzle spray angle, fuel pressure, or other parameters of the nozzle are acceptable if the fuel flow rate, flame temperature, and burner heat flux density conform to the requirements of section 8.6 of the handbook.

8.3.2.3 A fuel pressure regulator that is adjusted to deliver 2 ± 0.1 gal/hr (0.126 ± 0.0063 L/min) flow through the nozzle should be provided. An operating fuel pressure of 85 ± 4 psig (0.57 ± 0.03 MPa) for a 2.25 gal/hr (0.142 L/min) 80-degree spray angle nozzle has been found satisfactory.

8.3.2.4 Number 2 Grade diesel fuel, Jet A, or the international equivalent is the recommended fuel because it has been found to produce satisfactory results if the flow rate and inlet airflow conform to the requirements of sections 8.6 and 8.7 of the handbook.

8.3.4 The thermocouples are subjected to high temperatures durations during calibration. Because of this type of cycling, the thermocouples may degrade with time. Small but continuing decreases or extreme variations in temperature or "no" temperature reading at all are signs that the thermocouple or thermocouples are degrading or open circuits have occurred. In this case, the thermocouple or thermocouples should be replaced in order to maintain accuracy in calibrating the burner. It is recommended that a record be kept for the amount of time the thermocouples are exposed to the oil burner's flame.

8.3.5.2 The Omega microprocessor-based portable air velocity kit, model HH-30, is a recommended unit. The kit includes a vane-type air velocity sensor, hand-held digital readout displaying air velocity, extension rods, and a 9-volt lithium battery. Since the unit monitors air velocity in FPM or MPS ± 1 percent reading accuracy, necessary conversions must be made to attain airflow values. To do this, the area of the opening of the air sensor must be measured. Once the area is found, install the air velocity sensor at the oil burner inlet (see figure 8-7 for location). Following the procedures prescribed in section 8.6.1, this value should be multiplied by the air velocity reading. (The area of the air velocity sensor for the Omega model HH-30 is 0.037 ft² [0.0034 m²]. As an example, by maintaining an air velocity reading of 1800 ft/min using the Omega air sensor described above, an air flow of 67 ft³/min should be achieved.) If an air velocity sensor other than the Omega model HH-30 is being used, the same conversions apply.

$$\text{Airflow} = \text{Air Velocity} \times \text{Area of Opening (Air Velocity Sensor)}$$

8.6.1 An alternate method of airflow measurement involves removing the burner extension from the end of the draft tube. Turn on the blower portion of the burner without turning on the fuel or ignitors. Measure the air velocity using a hot-wire anemometer. Adjust the airflow using the damper so that the airflow is in the range of 1550 to 1800 ft/min (762 to 914 cm/second). (If tabs are being used, the tabs should be removed prior to measuring the airflow. After the measurement is complete, reinstall the tabs and the cone extension.)

8.7 Static Disks

Static disks were recently developed to stabilize the air before entering the combustion area. Two were designed by Park Oil Burner Manufacturing Company of Atlantic City, New Jersey. The Park Oil Burner disks are both made of steel. See figure 8-8 for details on the disks. Disks 1 and 2 are made for easy assembly, only requiring the removal of the draft tube and installation of the disk. Disk 3 was developed by CEAT, the French Ministry of Defense. The disk is made of a Nomex honeycomb material. CEAT uses two honeycomb disks positioned behind the stabilizer.

These disks are an optional feature and are used (any one or more of the three) to help produce a more full and even flame pattern. However, there is no guarantee of achieving calibration using a disk with all of the various makes and models of burners used throughout the industry.

8.7.3 A stainless steel wire brush is one possible cleaning tool. Soot buildup inside the burner cone can affect the flame characteristics and cause calibration difficulties. Since the burner cone may distort with time, dimensions will need to be checked periodically.

8.7.4 The airflow should be adjusted to produce the proper flame as well as the proper temperature and heat flux density. Two different flame profiles may yield the same temperature and heat flux density. The correct flame is generally 8 to 10 inches in length and orange-yellow in color.

8.7.8 Following are recommendations for achieving calibration temperatures and heat flux:

1. Set the stabilizer 3.25 ± 0.25 inches from the end of the draft tube.
2. Rotate the ignitor to the 6 o'clock and 9 o'clock position (viewpoint: looking toward the stabilizer from the end of the draft tube).
3. Seal all possible air leaks around the burner cone and draft tube area.
4. Use static disk to improve flame characteristics.
5. Replace thermocouples after 50 hours of use.

8.8.8.2 Test procedures for cargo liner design features are described in FAA Technical Note DOT/FAA/CT-TN88/33, dated September 1988.

8.10.1 Flames that may appear on the side of the specimen away from the burner or as a result of the ignition of flammable smoke and/or gases produced from the specimen by the heat from the burner do not constitute burnthrough. Burnthrough occurs only if the flame from the burner passes through the specimen.

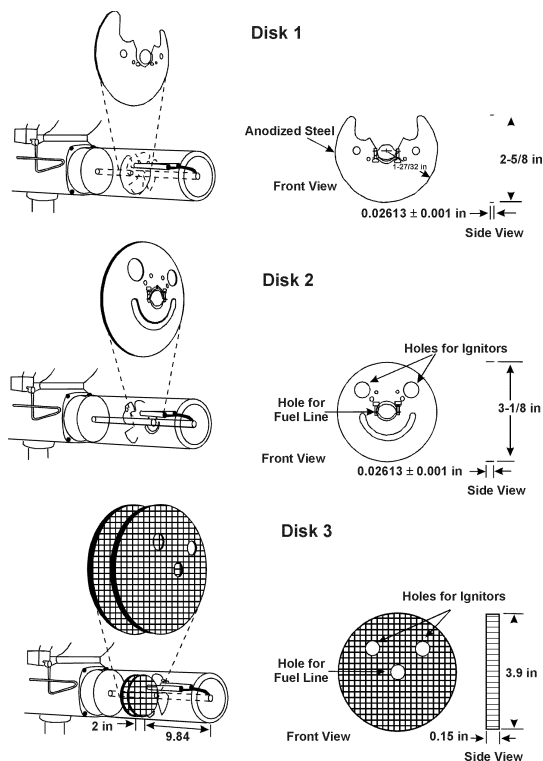


Figure 8-8. Static Disk Illustration

Chapter 9

Radiant Heat Testing of Evacuation Slides, Ramps, and Rafts

9.1 Scope

9.1.1 This method is used to show compliance to Technical Standard Order (TSO) C69A.

9.2 Definition

9.2.1 Time to Failure

The time to failure is the time between first application of heat to the specimen and the first decrease in pressure below the maximum pressure attained in the test cylinder during the test.

9.3 Test Apparatus

9.3.1 Pressure Cylinder and Specimen Holder

The pressure cylinder will consist of a 12 3/8-inch (314-mm) -long aluminum cylinder with a 7 inch (178 mm) outside diameter and a 6 1/2 inch (165 mm) inside diameter, as shown in figures 9-1, 9-2, and 9-3.

9.3.1.1 An aluminum plate 1/2 inch (13 mm) thick will be welded to one end of the cylinder and will be drilled and tapped near its upper edge for a 1/4-inch (6.4-mm) American Standard taper pipe thread to facilitate the hook up of air pressure and pressure recording equipment.

9.3.1.2 An aluminum ring 7 inches (178 mm) in outer diameter, 5 1/2 inches (140 mm) in inner diameter, and 1/2 inch (13 mm) thick will be welded to the other end of the cylinder. The ring will have eight evenly spaced 10-32 bolt holes on the circle 5/16 inch (8 mm) from the ring's inner edge. (The diameter of this circle is 6 1/8 inches [156 mm] and adjacent bolt holes are 2 5/16 inches [60 mm] apart.) A 10-32 steel bolt 7/8 inch (22 mm) long will be placed into each of the holes.

9.3.1.3 An aluminum ring, 6 3/4 inches (171 mm) in outer diameter, 5 1/2 inches (140 mm) in inner diameter, 1/2 inch (13 mm) thick, and two neoprene rubber gaskets with similar clearance holes to fit over the bolts will provide a means for clamping and sealing the test specimen in place. Hinges and adjustable stops will be welded to the sides of the cylinder, as shown in figures 9-1, 9-2, and 9-3.

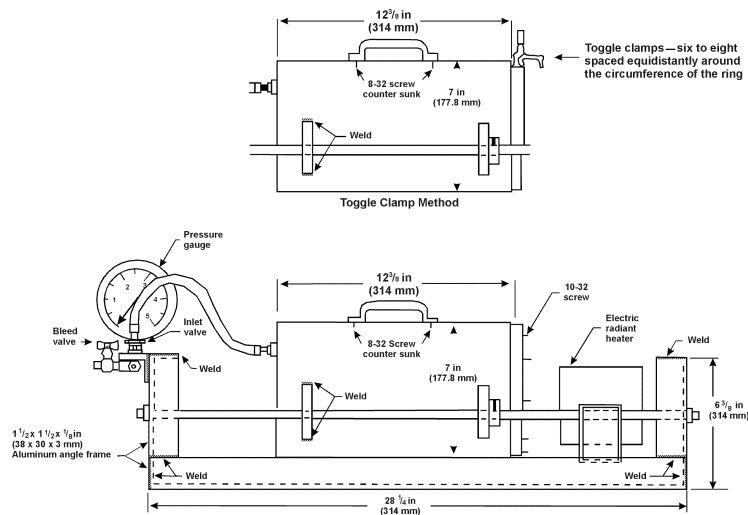


Figure 9-1. Evacuation Slide Material Test Apparatus – Front View

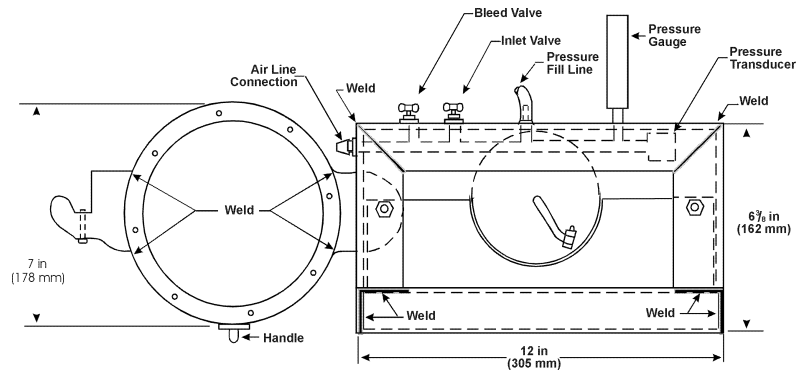


Figure 9-2. Evacuation Slide Material Test Apparatus – Side View

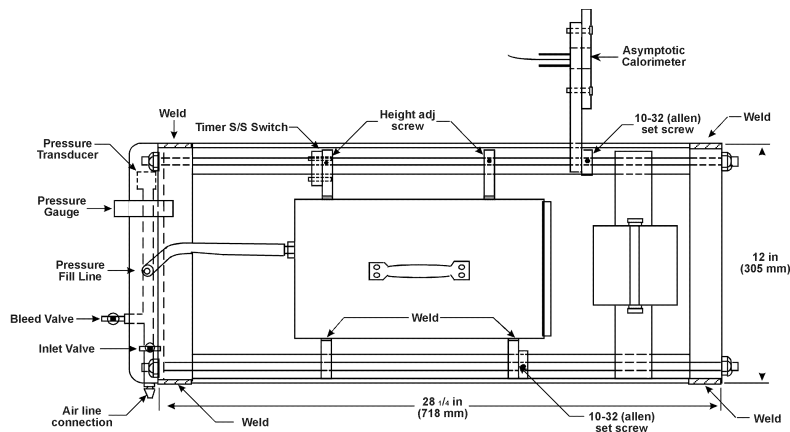


Figure 9-3. Evacuation Slide Material Test Apparatus – Top View

9.3.2 Electric Furnace

An electric furnace with a 3-inch (76-mm) -diameter opening, as shown in figure 9-4, will be provided to supply a constant irradiance on the specimen surface. The Smoke Density Chamber radiant heat furnace, or equivalent, has been found suitable.

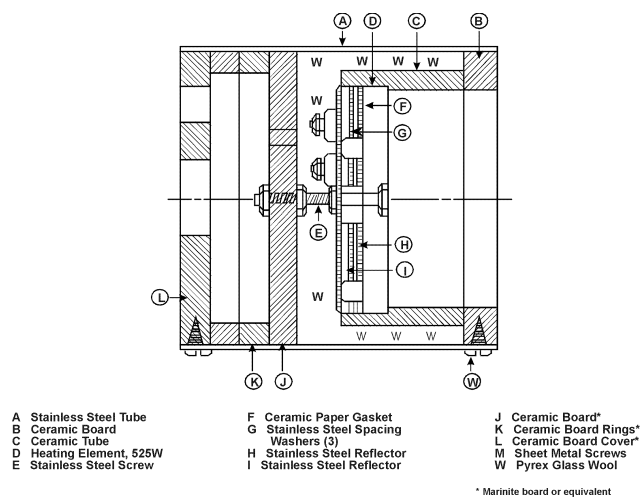


Figure 9-4. Furnace Details

9.3.3 Furnace Voltage Control

A variable voltage control, 115V, 600W minimum, will be provided to connect to the electric furnace power supply to adequately control the heat flux from the furnace. The furnace control system will be capable of maintaining the irradiance level under steady-state conditions for a minimum of 20 minutes.

9.3.4 Calorimeter

A 0 to 5 Btu/ft²-sec calorimeter will be provided to monitor the heat flux from the furnace. The calorimeter will be mounted in a 4 1/2-inch (114-mm) -diameter by 3/4-inch (19-mm) -thick insulating block, such as calcium-silicate millboard, with the surface of the calorimeter flush with the surface of the insulating block. The calorimeter will be hinged to one of the sliding bars of the framework and centered with the furnace (see figure 9-3).

9.3.5 Apparatus Framework

The pressure cylinder, calorimeter, and furnace are mounted on a framework, as detailed in figure 9-3. Adjustable sliding stops are located on each of the bars for setting the cylinder and calorimeter at any distance from the opening of the furnace.

9.3.6 Pressure Supply and Equipment

Compressed air is connected to the cylinder through a needle valve attached to the end of the framework. A tee-manifold on the outlet side of the valve provides for a 0 to 5 psig pressure gauge, a transducer, a flexible tube to supply air to the rear plate of the pressure cylinder, and a bleed valve, as shown in figure 9-1.

9.3.7 Instrumentation

The outputs of the calorimeter and pressure transducer are measured and recorded using a recording potentiometer or other suitable instrument capable of measurement over the range required.

9.4 Test Specimens

9.4.1 For each test, at least three specimens, 7 inches (178 mm) in diameter with eight 1/4-inch (6-mm) holes punched in the material to match the studs in the pressure cylinder, will be cut from the material to be tested.

9.4.2 If the pressure holding material has any exposed surfaces that are marked, overlay material, seams, or are altered in any other manner that affects radiant heat resistance, each different surface will be tested as a specimen set.

9.5 Conditioning

9.5.1 Condition test specimens at 70° ± 5°F (21° ± 3°C) relative humidity for a minimum of 24 hours prior to testing.

9.6 Calibration

9.6.1 Turn on the radiant heat furnace and other required instrumentation and allow 1/2 to 3/4 hours to stabilize heat output and for instrumentation warmup.

9.6.2 Adjust the transformer to produce a radiant heat flux density of 2 Btu/ft²-sec (2.3 W/cm²) when the calorimeter is positioned at approximately 1 1/2 inches (38 mm) in front of the radiant heat furnace.

9.6.3 Find the precise location in front of the furnace where the test heat flux density of 1.5 Btu/ft²-sec (1.7 W/cm²) is achieved by sliding the calorimeter on the horizontal bar and fixing the position with the sliding stop. Swing the calorimeter out of position.

9.7 Procedure

- 9.7.1 Conduct the tests in a draft free room or enclosed space. It is recommended that tests be conducted under a hood or other means to remove potentially hazardous gases from the test area.
- 9.7.2 Turn on the radiant heat furnace and other required instrumentation and allow 1/2 to 3/4 hours to stabilize heat output and for instrumentation warmup.
- 9.7.3 Rotate the cylinder away from the furnace. Mount the specimen with the reflective surface of the material facing the furnace on the open end of the cylinder and with a neoprene gasket on each side of the specimen. Place the aluminum ring on the studs and tighten the nuts so that an airtight seal is achieved.
- 9.7.4 Pressurize the cylinder to the slide material nominal operating pressure and check for leakage.
- 9.7.5 Locate the pressure cylinder so that the distance from the test specimen to the surface of the radiant heat furnace is the distance established in section 9.6.3.
- 9.7.6 Place the calorimeter in front of the radiant heat furnace at the distance established in section 9.6.3 and record the heat flux density. Verify that the heat flux is $1.5 \text{ Btu/ft}^2\text{-sec}$ (1.7 W/cm^2). Remove the calorimeter.
- 9.7.7 Rotate the pressure cylinder with the test specimen in front of the radiant heat furnace. Start the timer.
- 9.7.8 Monitor the pressure cylinder from the time the specimen is placed in front of the furnace until the first observed pressure loss.
- 9.7.9 Record time to failure in seconds.

9.8 Report

- 9.8.1 Report material description and full identification that may include type of fabric and coating, manufacturer, manufacturer style number, weight, thickness, color, and any alterations, if applicable.
- 9.8.2 Report the test conditions, including the heat flux density and starting pressure for each of the three specimens.
- 9.8.3 Report any observations of the material behavior during the test and times of occurrence.
- 9.8.4 Report the time to failure for each of the three specimens and the overall average.

9.9 Requirement

- 9.9.1 The average time to failure for the three specimens tested will not be less than 90 seconds.

Chapter 9 Supplement

This supplement contains advisory material pertinent to referenced paragraphs.

9.3.1 Figure 9-1 represents an alternative method of securing the specimen in place on the holder by using toggle clamps instead of welded hinges and adjustable stops.

9.3.2 The electric furnace is available from Superpressure, Inc., 8030 Georgia Avenue, Silver Springs, Maryland 20910 (Catalog Number #D-257-68086).

9.6.1 To prolong the life of the furnace, increase the voltage to cold furnace slowly.

Chapter 10

Fire Containment Test of Waste Stowage Compartments

10.1 Scope

- 10.1.1 These methods are intended for use in determining the fire containment capability of containers, carts, and compartments used to store combustible waste materials according to the requirements of FAR 25.853(e) through Amendment 51.
- 10.1.2 Parts construction used for the top, bottom, and sides of these compartments must meet the requirements of FAR 25.853 and FAR 25.855. These tests are covered elsewhere in this handbook in chapter 1, Vertical Bunsen Burner Test for Cabin and Cargo Compartment Materials, chapter 2, 45-Degree Bunsen Burner Test for Cargo Compartment Liners and Waste Stowage Compartment Materials, and chapter 4, 60-Degree Bunsen Burner Test for Electrical Wire.
- 10.1.3 There are multiple test arrangements covered in this specification: Entree Carts, Meal Carts, Waste Carts, and Waste Compartment Meal Boxes (see table 10-1 for meal boxes).

Table 10-1. Meal Box Test Arrangements

Equipment Description	Meal Box Stowed in Open Galley Compartment	Enclosed Galley Compartment	Open Cart Compartment	Enclosed Cart Compartment
Metalic meal box, complete enclosure	No test required	No test required	Test meal box within trolley compartment	Test trolley
Metalic meal box, incomplete enclosure	Uncertifiable for waste storage	Test meal box within the compartment	Uncertifiable for waste storage	Test meal box within trolley compartment
Nonmetallic meal box, complete enclosure	Test meal box (unstowed)	Test meal box (unstowed)	Test meal box within trolley compartment	Test trolley compartment with and without meal box
Nonmetallic meal box, incomplete enclosure	Uncertifiable for waste storage	Test meal box/compartment	Uncertifiable for waste storage	Test trolley compartment with and without meal box

10.2 Definitions

10.2.1 Air Ducting

Air ducting is used for conveying chilled air to and from carts.

10.2.2 Waste Cart

An enclosure on wheels that provides a means of accumulating and/or storing waste.

10.2.3 Meal Cart

An enclosure on wheels used to store food and used or unused service trays that might contain waste.

10.2.4 Entree Cart

An enclosure on wheels used to cook or store food at elevated temperatures and transport/store unused or used food service trays that might contain waste.

10.2.5 Integral Floor

The bottom panel of a waste compartment.

10.2.6 Waste Compartment (Galley or Lavatory Module)

An enclosure or shell structure with access provisions, such as a waste chute opening or doors, designed for the purpose of accumulating or storing waste.

10.2.7 Waste Container

A removable receptacle stored within a waste compartment or waste cart designed to accumulate or store waste within the compartment or cart.

10.2.8 Meal Box

A removable enclosure located in a meal trolley or galley compartment used to store food and used or unused service trays that might contain waste.

10.3 Test Apparatus/Equipment

10.3.1 Thermocouple(s)

A thermocouple may be needed to monitor internal test unit temperature.

10.3.1.1 If a thermocouple is used for meal or entree carts, it will be installed 1.5 to 2 inches above the top-most tray. A second thermocouple will be placed on the bottom tray in a similar manner.

10.3.1.2 For waste compartments/carts, a single thermocouple is inserted through the waste flap and placed 1.5 to 2 inches above the waste combustibles surface.

10.3.2 Thermocouple Readout/Recording

If used, thermocouples will be connected to a system that is capable of providing continuous temperature readings. A recording system will be used so that temperatures can be recorded continuously or at intervals not exceeding 15 seconds.

10.3.3 Galley

Galley structure is used to simulate the interface needed for the stowed cart test arrangements.

10.3.3.1 The galley structure will be equipped with power outlets and air inlet/outlet ducting to circulate ambient air at the design-specified airflow to the cart when set up to conduct testing.

10.3.4 Waste Materials

10.3.4.1 Combustibles

10.3.4.1.1 The meal cart arrangement includes the following combustibles:

One set of plastic eating utensils

One cup

One salad dish

One salad dressing container

One entree dish

One dessert dish

One crumpled 2-ply paper napkin, approximately 16 by 16 inches

The trays, each loaded with the above combustibles or equivalent representative materials found in service, will be inserted into the cart so that 75 percent of the trays are loaded in the cart starting from the bottom.

- 10.3.4.1.2 For the entree cart test arrangement, combustibles will consist of the same items per tray as for the meal cart for the stowed test. For fire source, the bottom tray will have an entree dish half filled with methyl alcohol to simulate grease. The napkin will not be located near the alcohol source. For the unstowed test, treat the entree cart as a meal cart.

- 10.3.4.1.3 For the waste compartment/waste cart, combustibles will be crumpled and consist of the following proportions of materials or an equivalent:

Eight 2-ply paper and towels, approximately 10 by 11 inches (40 percent by number)

Five 2-ply paper napkins, approximately 16 by 16 inches (25 percent by number)

Four 8-ounce paper hot drink cups (20 percent by number)

Two 3-ounce paper cold drink cups (10 percent by number)

One empty cigarette package (5 percent by number)

The total amount of the above crumpled combustibles in the above proportions will be sufficient to fill the waste compartment or waste container to three-fourths capacity.

10.4 Test Unit

- 10.4.1 The unit to be tested will be equivalent to an actual production unit, built to drawing specifications and tolerances.
- 10.4.2 A statement of conformity will be obtained for each test unit prior to testing.

10.5 Test Arrangements

10.5.1 Meal Cart Test Arrangements

- 10.5.1.1 The unstowed meal cart arrangement requires a condition where the cart is tested in a freestanding position. Photographs (refer to section 10.7.3) will show the door with the chilled air duct interfaces (if applicable).

- 10.5.1.2 Stowed Meal Cart

The stowed meal cart test arrangement requires the cart be installed in the galley cart compartment with the air inlet/outlet openings connected to the air ducting. During the test, air is to be circulated through the cart at the design flow rate. To simulate the cart/galley interface, photographs of the meal cart should be taken from the side to show the cart vendor. The maximum cart/galley misalignment will be reproduced during the test.

10.5.2 Waste Cart Arrangements

Testing both with and without the waste container is required if the waste container is nonmetallic. The waste cart interface with the galley (i.e., galley waste flap and waste chute) is also required to be simulated if the waste chute enters the cart enclosure and/or keeps the cart waste flap open.

- 10.5.2.1 An unstowed waste cart (waste container not installed) test arrangement requires a freestanding position at room temperature and still air. Photographs must be taken showing the cart door and flap.

- 10.5.2.2 An unstowed waste cart (waste container installed) test arrangement requires that the cart be in a freestanding position, per section 10.5.2.1, with the waste container installed.
- 10.5.2.3 A stowed waste cart (waste container not installed) test arrangement requires that the interface of the galley structure with the cart be simulated. The cart will be stowed in a galley mockup that completely simulates the galley/cart interface. Photographs will be taken that clearly show the waste chute/waste cart interface and the cart door during the test.
- 10.5.2.4 The stowed waste cart (waste container installed) arrangement is equivalent to section 10.5.2.3, except that a waste container is installed.

10.5.3 Entree Cart Arrangement

- 10.5.3.1 An unstowed entree cart test arrangement requires that the cart be tested in a freestanding position at room temperature and still air.
- 10.5.3.2 A stowed entree cart test arrangement requires that the cart be connected to the galley power and, if applicable, air ducting outlets. Power will be supplied to the cart for the duration of the test. All heaters and fans will be switched on with any timers set to the maximum duration. If the cart receives air from the galley ducting when the power is switched off, then a third test (stowed meal cart test arrangement) is required.

10.5.4 Waste Compartment Arrangements

- 10.5.4.1 The only condition in which waste compartments without an integral bottom or base panel are to be tested is with the waste container installed within the waste compartment. If a liner is used within the waste container, the test will be conducted both with and without the liner installed. Ambient condition will be room temperature and still air. Photographs will show the compartment door and the waste flap.
- 10.5.4.2 Waste compartments may be tested without a waste container for waste compartments with an integral floor. If the waste container is nonmetallic, then a waste compartment with an integral floor must be tested both with and without the waste container installed. If a liner is used within the waste container, the test will be conducted both with and without the liner installed.

10.5.5 Meal Box Arrangements

The different types and arrangements of meal boxes that require testing are defined in table 10-1. Meal boxes are to be tested in the same manner as a meal cart (see section 10.6.1).

10.6 Procedure

10.6.1 Ignition

10.6.1.1 Meal Cart

10.6.1.1.1 Stowed Meal Cart Test Arrangement

Ignite two crumpled 2-ply paper napkins, approximately 16 by 16 inches in size. Place them side by side adjacent to the combustibles, defined in section 10.3.4, already in place on the bottom tray the greatest possible distance from the air inlet/outlet openings of the cart. Allow a good flame front to develop by allowing approximately 50 percent of the surface of the waste materials to ignite. Insert the tray into the cart, record the temperature, and close the door. Place the cart into the simulated galley structure so that it is connected with the galley duct/cart interface. The airflow through the cart will be at the design airflow rate.

10.6.1.1.2 Unstowed Meal Cart Test Arrangement

Ignite two crumpled 2-ply paper napkins, approximately 16 by 16 inches in size. Place them side by side adjacent to the other combustibles, defined in section 10.3.4, already on the bottom tray. Allow a good flame front to develop by allowing approximately 50 percent of the surface of the waste materials to ignite. Insert the tray into the cart and simultaneously close the door and record the temperature, if the temperature is being monitored.

10.6.1.2 Entree Cart

10.6.1.2.1 Stowed Entree Cart

Connect the entree cart filled with the combustibles of section 10.3.4.1.2 to the power source and energize all heaters and/or fans. Ignite the methyl alcohol in the entree dish on the bottom tray by placing a burning napkin onto the tray. Insert the tray into the cart, close the cart door, and simultaneously record the temperature, if the temperature is being monitored.

10.6.1.2.2 Unstowed Entree Cart

Proceed per the unstowed meal cart test configuration of section 10.6.1.1.2.

10.6.1.3 Waste Cart

10.6.1.3.1 Stowed Waste Cart With Waste Container

Ignite a paper napkin and place it in the waste container through the waste flap. Allow a good flame front to develop by allowing 50 percent of the surface of the waste materials to ignite. Close the waste flap and simultaneously record the starting temperature.

10.6.1.3.2 Stowed Waste Cart Without Waste Container

Proceed per section 10.6.1.3.1, except that no waste container is used.

10.6.1.3.3 Unstowed Waste Cart With Waste Container

Proceed per section 10.6.1.3.1.

10.6.1.3.4 Unstowed Waste Cart Without Waste Container

Proceed per section 10.6.1.3.2.

10.6.1.4 For the waste compartment with and without waste container, proceed per applicable waste can arrangement, sections 10.6.1.3.1 and 10.6.1.3.2.

10.6.1.5 For the meal box, proceed per section 10.6.1.1.

10.6.2 Temperature

If the temperature is being monitored, it will rise rapidly, peak, and then fall below 150°F (66°C) as the flame dies out. The peak in temperature is necessary to identify that combustion has taken place. An example of this temperature peak is visualized in the temperature versus time plot shown in figure 10-1. When the temperature indicated by the thermocouple falls below 150°F (66°C), the test is terminated and the item examined for damage. If a suitable temperature peak above 150°F (66°C) is not obtained after three trials, sufficient ventilation will be provided to achieve a peak.

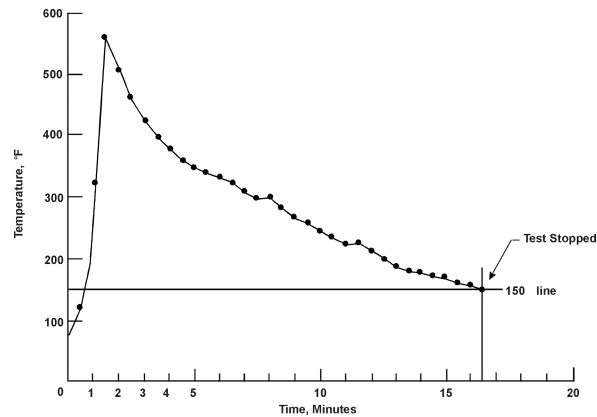


Figure 10-1. Sample Fire Containment Temperature versus Time Plot

10.6.3 Photographs

Photographs, preferably in color, are required to document the progress of the test. Suggested photographs that may be taken include the test unit before test, test setup, at time of ignition (with door or flap enclosed), at 30 seconds, 1 minute, 2 minutes, 3 minutes, 5 minutes, 7 minutes, and 10 minutes into the test, and at 5-minute intervals thereafter. Include detailed photographs showing any damage sustained as a result of the fire. Photographs taken during the test shall have a dark background to show smoke in contrast.

10.6.4 Inspection

After the test has been terminated, the test unit will be inspected for damage. The doors will be opened and the extent of combustion of the waste materials will be noted. Photographs will be taken of these waste materials and any damage to the cart or compartment, or lack of damage. Care should be taken to completely document any damage, from simple smoke stains and melting of trays to major burnthrough of any panels.

10.7 Report

10.7.1 Identification of Specimen

Completely identify the unit being tested and its intended use.

10.7.2 Description

The results of the test will be described in a concise manner regarding any observable smoke or fire from within the item. Any deterioration, burnthrough, or deformation of the panels caused by heat or flame will be noted and described along with the time of occurrence. Any damage to the item and/or surrounding structures during the test will be noted. Any damage to the contents will be described, including the degree of combustion of the articles placed within the unit, and damage to trays, seals, etc.

10.7.3 Temperature Versus Time Plot

A temperature versus time plot may be supplied in the report if temperature is monitored during the test. An example of a temperature versus time plot is shown in figure 10-1.

10.7.4 Test Photographs

The photographs taken (per section 10.6.3) of the test method will be included with the report. Photocopies of photographs are not acceptable. A short description will accompany each photograph.

10.7.5 Acceptance of Results

A statement as to whether the acceptance criteria are met will be made in the report.

10.7.6 Statement of Conformity

The statement of conformity sheet will be included with the test report.

10.7.7 Summary of Data

A summary may be prepared and included with the test report.

10.8 Requirements

- 10.8.1 The temperature indicated by the thermocouple(s), if used, after ignition will rise rapidly, peak, and then fall steadily as the fire burns out. To be valid, the test will have a definitive peak to demonstrate that a fire has taken place. If no peak is visible or a good flame front cannot be achieved, the test will be repeated up to three times to demonstrate that sufficient effort has been made to produce such a temperature peak or flame front.
- 10.8.2 The test unit will be able to contain a fire within the enclosure.
- 10.8.3 Fire/flame will not penetrate through or issue from the bottom, top, or sides of the waste compartment/container, and adjacent material will not be ignited by heat from the test article.
- 10.8.4 Smoke will be contained within the waste compartment/container to the extent that the smoke level produced in the cabin does not create a hazardous condition or interfere with firefighting procedures.

Chapter 10 Supplement

This supplement contains advisory material pertinent to referenced paragraphs.

10.2.5 An integral floor is part of the galley/cart waste compartment. It is not the aircraft floor panel.

10.5.1 Misalignment generally refers to maximum air gaps, maximum seal interfaces, minimum overlaps, etc., allowed by drawing tolerances. Misalignment must be simulated during testing because with repeated waste receptacle handling, seals are unlikely to remain airtight. Misalignment may be represented during the test by using a 3/4-inch-long shim to support the door opening representing the allowable tolerance in the design drawings.

Chapter 11

Powerplant Hose Assemblies Test

11.1 Scope

- 11.1.1 This test method is used to determine the fire resistance of high-temperature hose assemblies used in designated fire zones to damage due to flame and vibration for showing compliance with TSO C42, C53A, and C75.
- 11.1.2 The requirements and procedures of this test method vary according to hose materials and hose assembly application.

11.2 Definitions

11.2.1 Designated Fire Zone

A designated fire zone is defined as a region of the aircraft, such as engine and auxiliary power unit compartments designated to require fire detection and extinguishing equipment, and as appropriate, the use of materials that are fire resistant or fireproof.

11.2.2 Fireproof

Per FAR Part 1, (found in Subchapter A—Definitions, Part I—Definitions and Abbreviations) “in designated fire zones means the ability of materials to withstand the heat from a severe fire of extended duration at least as well as steel in dimensions appropriate for their purpose.”

Powerplant hose assemblies are demonstrated to be fireproof by meeting the requirements of this test for a flame exposure time of 15 minutes.

11.2.3 Fire Resistant

Per FAR Part 1, (found in Subchapter A—Definitions, Part I—Definitions and Abbreviations) “with respect to fluid carrying lines, fluid system parts, wiring, air ducts, fittings, and powerplant controls means the capacity to perform the intended functions under the heat and other conditions likely to occur when there is a fire at the place concerned.”

Powerplant hose assemblies are demonstrated to be fire resistant by meeting the requirements of this test for a flame exposure time of 5 minutes.

11.2.4 Class A Hose Assembly

A class A hose assembly is defined as a hose assembly capable of withstanding exposure to this fire test procedure for 5 minutes without failure (e.g., leaking circulating oil) per TSO C53a.

11.2.5 Class B Hose Assembly

A class B hose assembly is defined as a hose assembly capable of withstanding exposure to this fire test procedure for 15 minutes without failure (e.g., leaking circulating oil) per TSO C53a.

11.2.6 Velometer

A device for measuring airflow velocity.

11.2.7 Photocell

An electronic device having output that varies in response to the intensity of incident visible light.

11.3 Apparatus

11.3.1 Test Burner

A modified gun-type conversion oil burner as described in table 11-1 will be used. The burner will be calibrated to provide a minimum average flame temperature of 2,000°F (1,100°C) and a minimum

Table 11-1. Test Burner Information

Burner Standard Model Designation	Power Supply	Test Nozzle	Test Fuel Flow -0, +0.05 gal/hr (95-psig pump press ref)	Test Air Pressure in Draft Tube (ref) 0.14 in H ₂ O	Modifications to Standard Burner
Stewart Warner HPR-250 This burner is no longer available. Supplier Stewart-Warner Corp. Heating & Air Conditioning Lebanon, Indiana 46052	1/4 HP/115V/ 60Hz/single ph	2.25 gal/hr 80-degree angle	2 gal/hr (95-psig pump press ref)	0.14 in H ₂ O	<ol style="list-style-type: none"> 1. Air tube diameter reduced to 2.5 inches (63.5 mm), starting 1.5 inches (38 mm) forward of nozzle tip. 2. Added four 3/4- by 1/16-inch (19- by 1.59-mm) stainless steel fuel deflector mounted on the reducing cone at 3, 6, 9, and 12 o'clock. The deflector edges were 3.4 inches (19 mm) off center line (CL) and 3.4 inches (19 mm) forward of fuel nozzle up. 3. Added static air pressure port 1 inch (25.4 mm) forward of the burner tube mounting flange. 4. Added a 12.5 inch (317.5 mm) burner extension so that the wide end is 10 inches (254 mm) beyond the end of the air tube.
Stewart Warner FR-600 This burner is no longer available. Supplier Stewart-Warner Corp. Heating & Air Conditioning Lebanon, Indiana 46052	1/3 HP/115V/ 60Hz/single ph	Same as above	2 gal/hr (100-psig pump press ref)	0.01 in H ₂ O	<ol style="list-style-type: none"> 1. Air tube diameter reduced to 2.5 inches (63.5 mm), starting 1.5 inches (38 mm) forward of nozzle tip. 2. Added four 3/4- by 1/16-inch (19- by 1.59-mm) stainless steel fuel deflector mounted on the reducing cone at 3, 6, 9, and 12 o'clock. The deflector edges were 3.4 inches (19 mm) off CL and 3.4 inches (19 mm) forward of fuel nozzle up. 3. Added static air pressure port 1 inch (25.4 mm) forward of the burner tube mounting flange. 4. Added a 12.5-inch (317.5-mm) burner extension so that the wide end is 10 inches (254 mm) beyond the end of the air tube.
Lennox OB-32 (This is now obsolete and cannot be purchased.)		2.25 gal/hr 80-degree angle	2 gal/hr (80-psig pump press ref)	0.17 in H ₂ O	<ol style="list-style-type: none"> 1. Add a 12.5-inch (317.5 mm) burner extension.

Table 11-1. Test Burner Information—(Continued)

Burner Standard Model Designation	Power Supply	Test Nozzle	Test Fuel Flow -0, +0.05 gal/hr (97-lb/in ² pump press ref)	Test Air Pressure in Draft Tube (ref)	Modifications to Standard Burner
Carlin 200CRD This burner is not available with modifications. Supplier Carlin Co. 912 Silas Dean Hwy Wethersfield, Conn. 06109	1/4 HP/115V/ 60Hz/single ph	Same as above	2 gal/hr (97-lb/in ² pump press ref)	0.37 in H ₂ O	<ol style="list-style-type: none"> Disassemble the burner air tube assembly and remove the throttle ring and the retention ring. Remove the existing fuel nozzle and install an 80-degree, 2.25- gal/hr nozzle. After reassembly, adjust the OD delivery rate to 2.01 gal/hr at 97 lb/in² gauge. Using 1/16 inch stainless steel material, manufacture and install three deflectors. Manufacture a flat-disk plate to match the inside diameter of the burner air tube and randomly punch 10 1/2-inch holes as shown. The main purpose of this disk is to center the oil delivery tube. Locate and punch holes for the ignitors and the oil delivery tube. A pie-shaped segment was cut out for ease of installation and the split-baffle mounting bracket was secured to the oil delivery tube with a small hose clamp. Position this flat-disk plate 4 inches aft of the fuel nozzle. Manufacture and install a reducing cone. The outside diameter of this cone should match the inside diameter of the oil burner air tube. This cone is secured in place with small Allen or socket head screws. Install the static pressure port 1 inch forward of the air tube mounting flange and adjust the air pressure in the air tube to approximately 0.37 inch of H₂O during operation. Manufacture a 12 1/2-inch burner air tube extension and install this extension so that the wide end is 10 inches beyond the end of the burner air tube.

Table 11-1. Test Burner Information—(Continued)

Burner Standard Model Designation	Power Supply	Test Nozzle	Test Fuel Flow -0, +0.05 gal/hr	Test Air Pressure in Draft Tube (ref)	Modifications to Standard Burner
Park DPL 3400 Supplier Park Manufacturing Company New York and Absecon Blvd. Atlantic City, New Jersey 08401					This burner will be built to the FAA's specifications upon request.

heat input of 4,500 Btu/hr to the Btu heat transfer device described in section 11.3.3.2, or 9.3 Btu/ft²-sec (10.6 W/cm²) as measured by a calorimeter described in section 11.3.3.1.

11.3.1.1 Burner Extension

A stainless steel funnel extension, fabricated in accordance with figure 11-1, will be used. The funnel will have an oblong exit 6 inches (152 mm) high by 11 inches (279 mm) wide. The funnel will be installed on the burner with the air tube shown in figure 11-2.

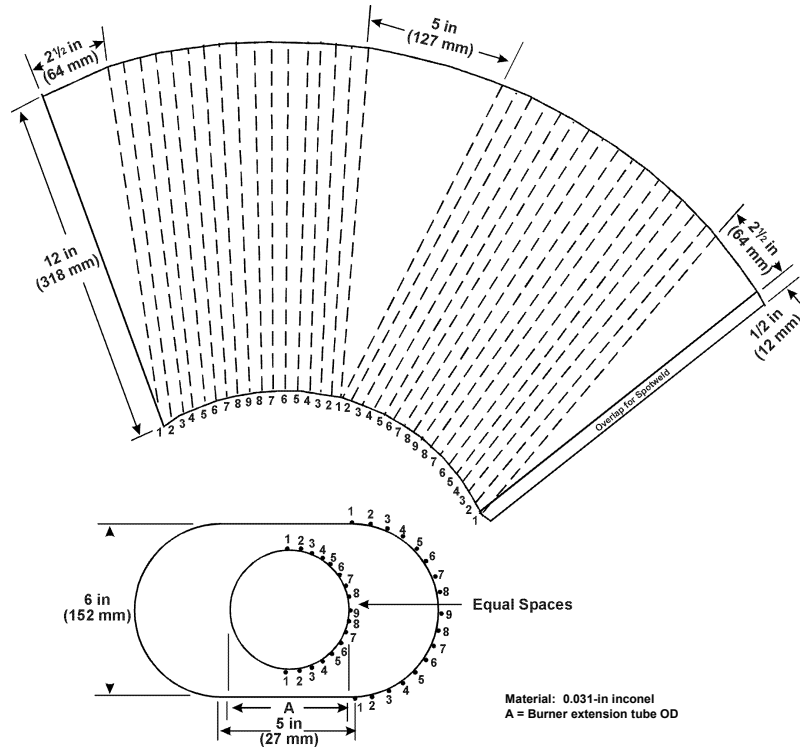


Figure 11-1. Burner Extension Funnel

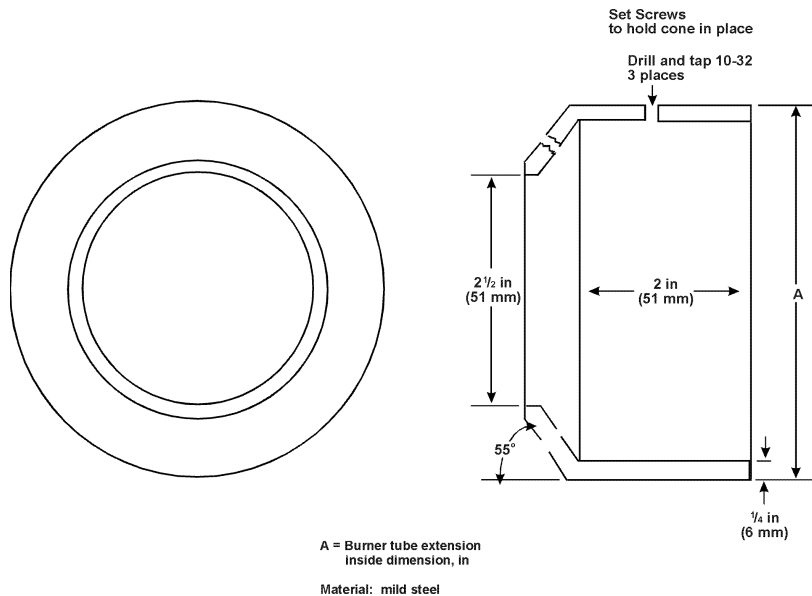


Figure 11-2. Air Tube Reducing Cone

11.3.1.2 Burner Fuel

Society of Automotive Engineers (SAE) No. 2 diesel, kerosene, or equivalent will be used for burner fuel.

11.3.2 Thermocouples

A thermocouple rake containing at least five American National Standard Institute (ANSI) 22-gauge Chromel-Alumel (Type K) thermocouple sheathed in 1/16-inch (1.6-mm) -thick stainless steel or inconel tubes, or equivalent, will be provided. The thermocouples will be aligned in a row 1 ± 0.1 inch (25 ± 3 mm) apart.

11.3.3 Heat Flux Measuring Device

One of the following devices will be used to measure the heat flux density of the flame.

11.3.3.1 Calorimeter

A water-cooled calorimeter capable of measuring heat flux densities up to $15 \text{ Btu/ft}^2\text{-sec}$ (17 W/cm^2) may be provided for burner calibration. A Hy-Cal model 1300A total heat flux density calorimeter available from Hy-Cal Engineering, Santa Fe Springs, California, or equivalent has been found suitable.

11.3.3.2 Btu Heat Transfer Device

Figures 11-4 to 11-10 show fabrication details of an acceptable copper tube device used to measure heat flux density. The mercury thermometers will be positioned in the mounting tubes so that the bottom of the bulb is within 1/16 inch (1.6 mm) of the bottom of the passage in the heat transfer tube (see figures 11-7 and 11-8).

11.3.3.2.1 Thermometers

Two glass scientific thermometers calibrated in 0.05°C (0.1°F) increments, immersible thermocouples, or equivalent will be provided for the heat transfer tube assembly.

11.3.4 Test Setup

A steel table measuring 60 inches (1,524 mm) wide, 28 inches (711 mm) deep, and 32 inches (813 mm) high has been found acceptable. The vibrating mechanism and hood, described below, may be mounted on this table. See figure 11-1 for an acceptable test setup.

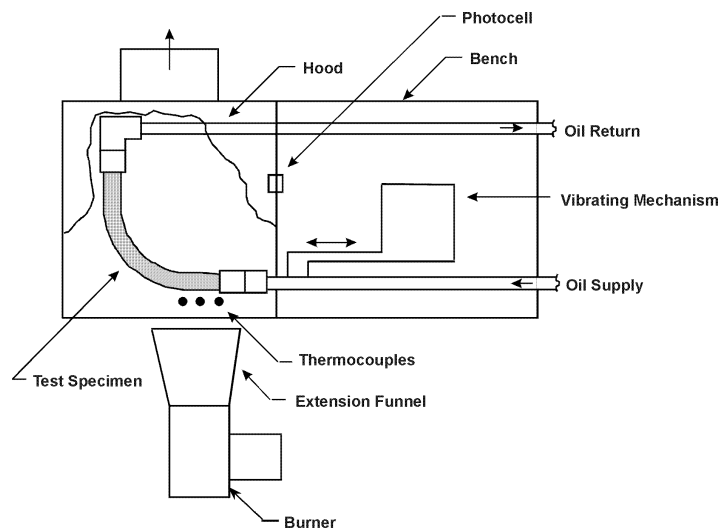


Figure 11-3. Hose Assemblies Test Setup

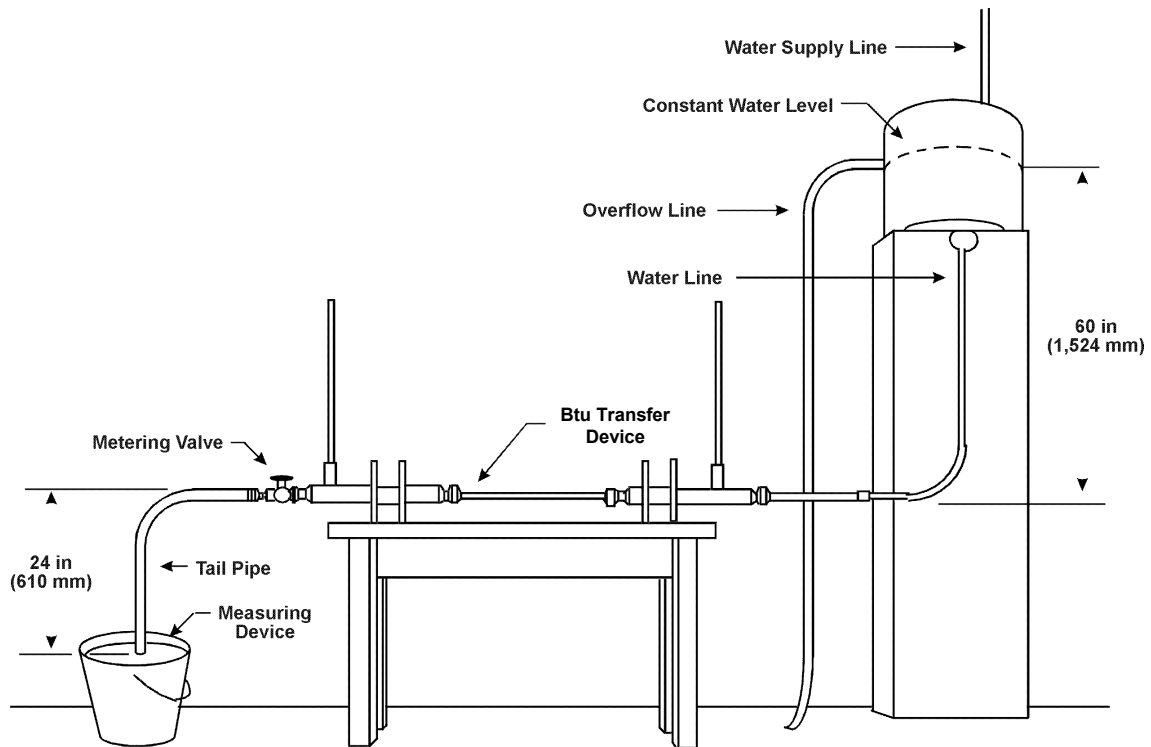


Figure 11-4. Burner Calibration Standardization Apparatus

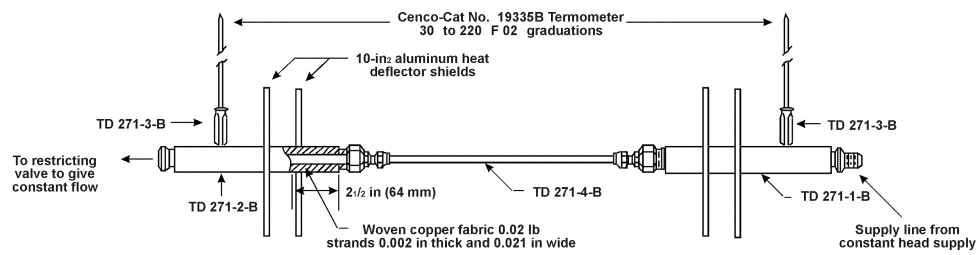


Figure 11-5. Btu Heat Transfer Device

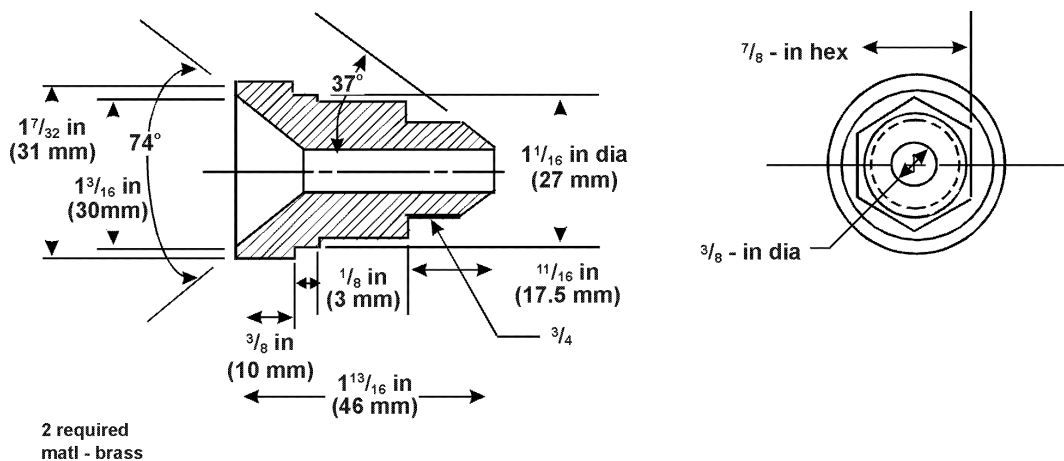


Figure 11-6. Btu Heat Transfer Device—Reducer

Material
(Alternate material may be used provided
thermal conductance is equivalent)
1 $\frac{7}{16}$ -in OD x $\frac{13}{16}$ -in ID x 12 in

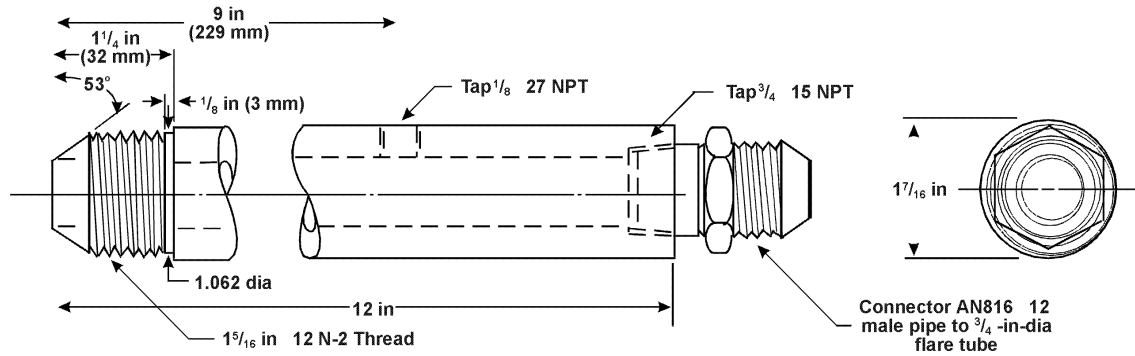


Figure 11-7. Btu Heat Transfer Device—Inlet Tube

Material—Transit Asbestos-Based Tubing
(Alternate material may be used provided
thermal conductance is equivalent)
1 $\frac{7}{16}$ -in OD x $\frac{13}{16}$ -in ID x 12 in

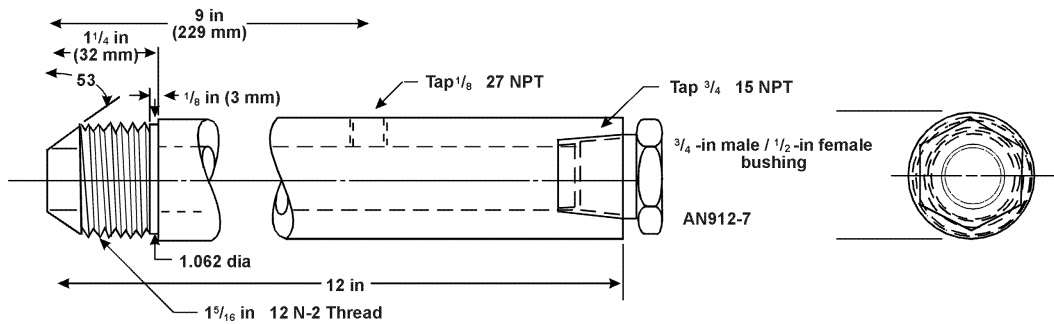


Figure 11-8. Btu Heat Transfer Device—Outlet Tube

Two required
Material: brass, $\frac{9}{16}$ -in hex x $3 \frac{3}{4}$ in

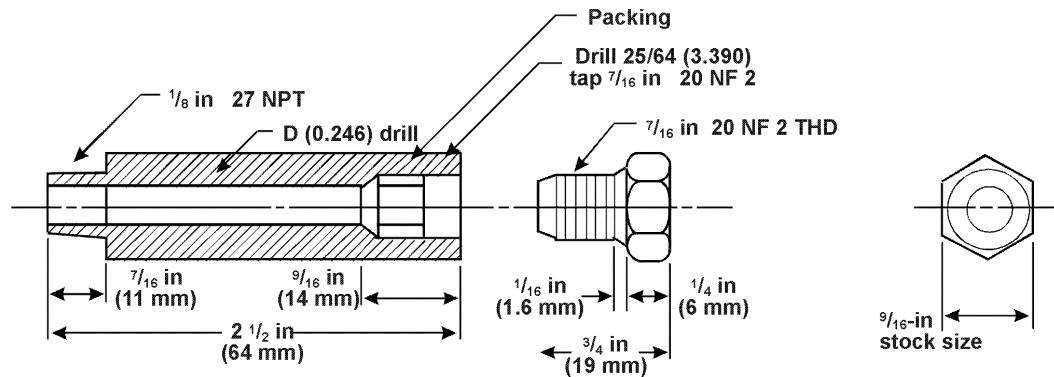


Figure 11-9. Btu Heat Transfer Device—Thermometer Mounting

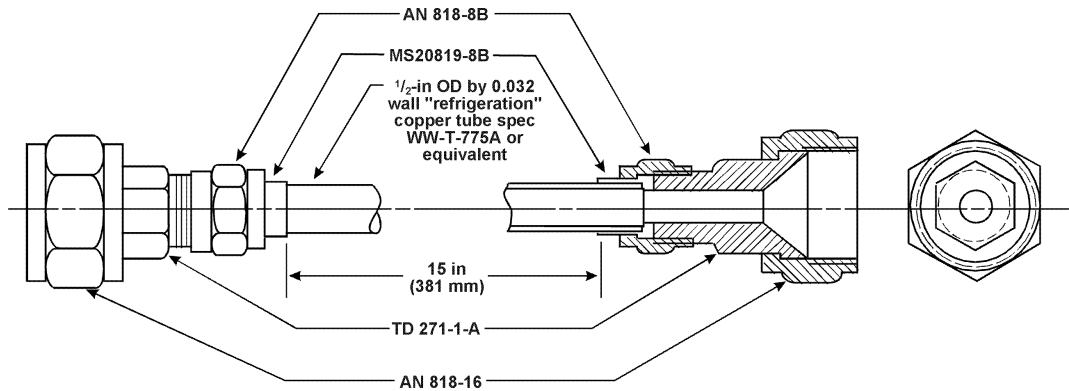


Figure 11-10. Btu Heat Transfer Device—Test Specimen

11.3.4.1 Vibration Source

A means will be provided to vibrate the hose assembly as shown in figure 11-8 at 33 Hz with a total displacement of at least 1/8 inch (3.2 mm), i.e., with an amplitude of at least 1/16 inch (1.6 mm).

11.3.4.2 Hood

A hood measuring 25 inches (635 mm) wide and 25 inches (635 mm) high has been found acceptable. The hood may be placed on the bench near the vibration source so that the vibrating fitting for the hose attachment is located 7 inches (178 mm) behind the open front of the hood.

11.3.4.2.1 Fan

The hood will have a fan installed on the rear to draw air through it at a velocity of 400 ft/min (203 cm/s), as measured by a velometer located at the position occupied by the hose assembly specimen during the test.

11.3.4.2.2 Photocell

The hood may contain a photocell to detect a flareup resulting from burning oil due to a hose failure.

11.3.4.3 Automatic Shutdown System

If a flareup of burning oil escaping from a failed hose assembly is detected, an automatic shutdown system may be provided to terminate the test by turning off the burner, vibrating mechanism, hood fan, and oil flow.

11.3.4.4 Temperature Measuring and Recording Equipment

A temperature sensing system will be provided that includes a sufficient number of thermocouples to ensure that the specified temperature exists along the entire end fitting and along the hose for a distance of not less than 5 inches (127 mm). The system will include a recorder to monitor the flame temperature throughout the fire test duration.

11.3.5 Oil Circulator and Heater

A device consisting of an oil tank with a temperature-controlled immersion heater and an electric oil pump will be provided if the hose assembly being tested must have oil pumped through the hose(s) during the test. The plumbing will include appropriate flow indicators, pressure gauges, control and selector valves, and pressure relief valves.

11.3.5.1 Oil

SAE No. 20 oil, in accordance with Military Specification MIL-L-2104C or equivalent, will be provided and used in the oil circulator and heater to pump through the hose assembly test specimen during the test.

11.4 Test Specimens

- 11.4.1 Prepare three specimens, 24 inches (610 mm) long, for the test.
- 11.4.2 The configuration of the hose test specimens will be as used in service. A firesleeve may be added to the hose assembly, if needed, to enable the test specimens to withstand the fire test duration specified.

11.5 Calibration

- 11.5.1 Place the thermocouple rake on the test stand at a distance 4 inches (102 mm) above the centerline of the burner extension. Connect the thermocouples to a stripchart recorder.
- 11.5.2 Light the burner, allow a 3-minute warmup, and move the burner into test position.
- 11.5.3 Begin monitoring the temperatures indicated by the thermocouples after 3 minutes. Make adjustments as necessary to either the gas flow or the airflow to the burner in order to achieve a minimum average thermocouple reading of 2,000°F (1,100°C).
- 11.5.4 Turn the burner off, move it out of test position, and remove the thermocouple rake.
- 11.5.5 Replace the thermocouple rake with the heat flux measuring device. Follow section 11.5.5.1 if using a water-cooled calorimeter for measuring heat flux. Follow section 11.5.5.2 if using a Btu heat transfer device for this purpose.
 - 11.5.5.1 If using the water-cooled calorimeter described in section 11.3.3.1, place the calorimeter at the same distance as the thermocouple rake centered over the burner exit.
 - 11.5.5.1.1 Light the burner, allow a 2-minute warmup, and move the burner into test position.
 - 11.5.5.1.2 Measure the heat flux density continuously or at intervals no greater than 10 seconds. If the heat flux density is not at least 9.3 Btu/ft²-sec (10.6 W/cm²), readjust the burner to achieve the proper heat flux. If burner adjustments are necessary, remove the heat flux measuring device and repeat sections 11.5.1 through 11.5.5.1.2.
 - 11.5.5.2 If using the Btu heat transfer device described in section 11.3.3.2, ensure the external surface of the copper tubing on the Btu heat transfer device is clean prior to measuring heat flux. Use fine steel wool to clean the copper tubing. Inspect the tubing bore for corrosion and/or scale accumulation and remove before each test. A .45-caliber pistol cleaning brush, or equivalent, with an extension has been found suitable for this purpose.
 - 11.5.5.2.1 The calibration setup is shown in figure 11-3. Provide a 5-foot (1.5 m) constant head of water above the heat transfer device and a 2-foot (0.61 m) drop to the end of the tailpipe for adjustment of the water flow rate. Use a 1 gallon (3.8 L) measuring container (a container and a weighing scale are also acceptable). Adjust the water flow rate to 500 lb/hr (227 kg/hr) or 1 gal/min (3.8 L/min). Supply water at a temperature of 50 to 70°F (10 to 21°C).
 - 11.5.5.2.2 Start the water flowing through the Btu heat transfer device. Center the heat transfer tube in the flame at the same location that a hose assembly would be placed for testing. Allow a 2-minute warmup period to stabilize flame conditions before temperature measurements from the mercury thermometers are recorded.

- 11.5.5.2.3 After the warmup period, record the inlet and outlet temperatures every 30 seconds for a 3-minute period. Determine the rate of Btu increase of the water as follows:

$$\begin{aligned}\text{Heat transfer} &= 146 \times (T_o - T_i) \text{ watts (for Celsius)} \\ &= 500 \times (T_o - T_i) \text{ Btu/hr (for Fahrenheit)}\end{aligned}$$

where: T_o = temperature ($^{\circ}\text{C}$ or $^{\circ}\text{F}$) at outlet

T_i = temperature ($^{\circ}\text{C}$ or $^{\circ}\text{F}$) at inlet

- 11.5.5.2.4 The heat rate output, as determined by the equation shown in section 11.5.5.2.3, will be a minimum of 4,500 Btu's per hour. If the heat output from the burner is not above this minimum, make adjustments to the burner and repeat sections 11.5.1 through 11.5.5.2 until the burner is within tolerance.

11.6 Procedure

11.6.1 Specimen Mounting

Mount the hose assembly in the test setup to include at least one full 90-degree bend so that the pressure existing inside the hose will exert an axial force on the hose end fitting. Locate the hose assembly 4 inches (102 mm) beyond the burner barrel extension so that the entire hose assembly end fitting and at least a minimum 5 inches (127 mm) of the hose is exposed to the flame. Install the entire hose assembly inside the hood unless limited by the physical characteristics of the hose such as minimum bend radius (see figure 11-1).

- 11.6.2 Preheat the oil in the oil tank to $200^{\circ} \pm 10^{\circ}\text{F}$ ($93^{\circ} \pm 6^{\circ}\text{C}$). Start the oil circulating pump and circulate the oil through the test hose assembly at a flow rate and pressure as specified by hose type, size, and application. Pressures and flow rates are as shown in table 11-2.

Table 11-2. Circulating Oil Pressure and Flow Rate

Hose Type	Circulating Oil		
	Pressure	Flow Rate	
		GPM	L/min
1a	System Working	$5 \times \text{ID (in)}^2$	$0.03 \times \text{ID (mm)}^2$
1b	System Working	$1 \times \text{ID (in)}^2$	$0.006 \times \text{ID (mm)}^2$
11a	System Working	$5 \times \text{ID (in)}^2$	$0.03 \times \text{ID (mm)}^2$
11b	System Working	$1 \times \text{ID (in)}^2$	$0.006 \times \text{ID (mm)}^2$

- 11.6.3 Start the vibrating mechanism and observe the movement of the hose. Ensure that no whipping of the hose occurs.
- 11.6.4 Start the hood air fan and begin monitoring the thermocouple recorder.
- 11.6.5 Start the burner. Periodically observe the recorded temperature to ensure that the required minimum flame temperature of $2,000^{\circ}\text{F}$ ($1,093^{\circ}\text{C}$) is maintained.
- 11.6.6 If a flareup of burning oil occurs due to a hose failure, terminate the test.
- 11.6.7 After the required test duration has been reached (i.e., 5 minutes for class A hose assemblies and 15 minutes for class B hose assemblies), terminate the test.
- 11.6.7.1 Stop the burner.
- 11.6.7.2 Relieve the oil pressure in the hose assembly.
- 11.6.7.3 Turn off the temperature recorder.

11.7 Report

- 11.7.1 Fully identify the hose configuration, including the assembly and fittings, and the class for which it is being tested.
- 11.7.2 Report if there were any flareups of leaking oil and any other pertinent observations.
- 11.7.3 Report whether the hose configuration met the requirements of class A or class B assemblies.

11.8 Requirements

11.8.1 Class A Hose Assembly

A class A assembly will withstand the test procedure in section 6 for at least 5 minutes without leaking circulating oil.

11.8.2 Class B Hose Assembly

A class B hose assembly will withstand the test procedure described in section 6 for at least 5 minutes without leaking circulating oil.

Chapter 11 Supplement

This supplement contains advisory material pertinent to referenced paragraphs.

11.2.6 A velometer manufactured by Alnor Instrument Company, 7555 North Linder Avenue, Skokie, Illinois 60077-3822, catalog number 01518, has been found satisfactory.

11.3.3.2 A satisfactory version of the woven copper fabric shown in figure 11-5 is manufactured by Metal Textile Corporation, Roselle, New Jersey.

11.3.4.4 Permanent installation of temperature measuring thermocouples and continuous recorder has been added for better control of the flame temperature during calibration and test.

11.4.2 If a firesleeve is required to be added for a hose type to pass the test, a firesleeve must be fitted to that hose type before it can be used in designated fire zones on an airplane.

11.6.2 Flow rate values given in table 11-2 were derived from the most recent TSO C53. Flow rates used for the test will be minimum flow rates given for the actual installation, if known.